United States Environmental Protection Agency

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Office of Federal Activities
NEPA Compliance Division

§309 Reviewers Guidance for New Nuclear Power Plant Environmental Impact Statements

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§309 Reviewers Guidance for New Nuclear Power Plant Environmental Impact Statements

Guidance for EPA Staff

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EXECUTIVE SUMMARY

This guidance provides background information to staff within the U.S. Environmental Protection Agency (EPA) who review and comment on National Environmental Policy Act (NEPA) documents prepared by the Nuclear Regulatory Commission (NRC), in accordance with EPA's responsibilities for environmental review under §309 of the Clean Air Act. Specifically, this guidance provides information to assist EPA reviewers to:

1. Prepare scoping comments on environmental impact statements (EISs) related to NRC's licensing of new nuclear power plants;
2. Consider those issues most appropriate to a specific type of nuclear reactor presented in an EIS;
3. Support the development of EPA's comments under Clean Air Act §309; and
4. Determine the adequacy of an EIS in terms of addressing the requirements pursuant to NEPA, NRC's NEPA-implementing regulations, applicable case law, and the threshold of significance for individual resources.

After presenting background information on the statutory and policy framework for nuclear power development in the U.S., and technical information on current and future reactor technology, this document highlights the resources and associated impacts on which EPA reviewers may wish to focus their efforts, including lists of questions and highlighted examples.

EPA reviewers may particularly want to refer to Appendices F and H of this document. Appendix F compiles the review question lists that are included throughout the document into a single list, and Appendix H presents a list of useful reference tools for reviewers of a nuclear power plant EIS.

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Acronyms and Glossary

Acronyms

4S	Toshiba Super Safe, Small and Simple
ABWR	Advanced Boiling Water Reactor
ACR	Advanced CANDU Reactor
ALARA	as low as reasonably achievable
AP	advanced passive
ATWS	anticipated transient without scram
BWR	boiling water reactor
CANDU	Canada Deuterium Uranium (reactor design)
CEQ	Council on Environmental Quality
COL	combined license
CP	construction permit
DOE	U.S. Department of Energy
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
EPR	European Power Reactor
ESBWR	Economic and Simplified Boiling Water Reactor
ESP	Early site permit
ESRP	Environmental Standard Review Plan
FSAR	final safety analysis report
GFR	gas-cooled fast reactor
GT-MHR	Gas Turbine – Modular Helium Reactor
gpm	gallons per minute
GPS	global positioning system
IAEA	International Atomic Energy Agency
IRIS	International Reactor Innovative and Secure
ITAAC	inspection, test, analysis, and acceptance criteria
km	kilometers
LFR	lead-cooled fast reactor
LOCA	loss-of-coolant accident
LWA	limited work authorization
m^3/s	cubic meters per second

MOX	mixed oxide fuel
mrem	millirem
MSR	molten salt reactor
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPP	nuclear power plant
NRC	U.S. Nuclear Regulatory Commission
NUREG	NRC documents; see further description in Glossary
OFA	Office of Federal Activities
OL	operating license
PBMR	Pebble Bed Modular Reactor
PM_{10}	particulate matter less than 10 micrometers in diameter
PPE	plant parameter envelope
PRA	probabilistic risk assessment
PWR	pressurized water reactor
QA	Quality Assurance
SCWR	supercritical-water-cooled reactor
SER	safety evaluation report
SFR	sodium-cooled fast reactor
SHPO	State Historic Preservation Officer
SWR	Siedewasser Reactor
USACE	U.S. Army Corps of Engineers
US-APWR	U.S. Advanced Pressurized Water Reactor
USGS	U.S. Geological Survey
VHTR	very-high-temperature reactor

Glossary

This glossary is compilation of terms and definitions from existing NRC[1], EPA[2], and DOE[3] glossaries, and includes terms used throughout this guidance document, as well as some that reviewers may encounter in NPP EISs.

Air Quality Criteria: The levels of pollution and lengths of exposure above which adverse health and welfare effects may occur.

Air Quality Standards: The level of pollutants prescribed by regulations that are not be exceeded during a given time in a defined area.

Airborne Particulates: Total suspended particulate matter found in the atmosphere as solid particles or liquid droplets. Chemical composition of particulates varies widely, depending on location and time of year. Sources of airborne particulates include: dust, emissions from industrial processes, combustion products from the burning of wood and coal, combustion products associated with motor vehicle or non-road engine exhausts, and reactions to gases in the atmosphere.

As low as reasonably achievable (ALARA) An approach to radiation protection to manage and control worker and public exposures (both individual and collective) and releases of radioactive material to the environment to as far below applicable limits as social, technical, economic, practical, and public policy considerations permit. ALARA is not a dose limit but a process for minimizing doses to as far below limits as is practicable.

Aquifer: An underground geological formation, or group of formations, containing water. Sources of groundwater for wells and springs.

Attainment area An area that the Environmental Protection Agency has designated as being in compliance with one or more of the National Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others.

Background radiation: Radiation from cosmic sources; naturally occurring radioactive materials, including radon (except as a decay product of source or special nuclear material) and global fallout as it exists in the environment from the testing of nuclear explosive devices. It does not include radiation from source, byproduct, or special nuclear materials regulated by the Nuclear Regulatory Commission. The typically quoted average individual exposure from background radiation is 360 millirem per year.

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[1] U.S. Nuclear Regulatory Commission. 2007. Glossary. Web site updated June 5, 2007. http://www.nrc.gov/reading-rm/basic-ref/glossary.html

[2] U.S. Environmental Protection Agency. 1997. Terms of environment: Glossary, abbreviations, and acronyms. December 1997. http://www.epa.gov/OCEPAterms/intro.htm

[3] U.S. Department of Energy. 1998. Glossary of terms used in NEPA documents. Office of NEPA Policy and Assistance. September 1998. http://www.eh.doe.gov/nepa/tools/guidance/glossary.pdf

Benthic/Benthos: An organism that feeds on the sediment at the bottom of a water body such as an ocean, lake, or river.

Best Management Practice (BMP): Methods that have been determined to be the most effective, practical means of preventing or reducing pollution from non-point sources.

Biochemical Oxygen Demand (BOD): A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Biological Oxygen Demand (BOD): An indirect measure of the concentration of biologically degradable material present in organic wastes. It usually reflects the amount of oxygen consumed in five days by biological processes breaking down organic waste.

Biota: The animal and plant life of a given region.

Boiling water reactor (BWR): A reactor in which water, used as both coolant and moderator, is allowed to boil in the core. The resulting steam can be used directly to drive a turbine and electrical generator, thereby producing electricity.

Byproduct: Byproduct is (1) any radioactive material (except special nuclear material) yielded in, or made radioactive by, exposure to the radiation incident to the process of producing or using special nuclear material (as in a reactor); and (2) the tailings or wastes produced by the extraction or concentration of uranium or thorium from ore (see 10 CFR 20.1003).

Cask: A heavily shielded container used to store and/or ship radioactive materials. Lead and steel are common materials used in the manufacture of casks.

Compaction: Reduction of the bulk of solid waste by rolling and tamping.

Cone of Depression: A depression in the water table that develops around a pumped well.

Containment structure: A gastight shell or other enclosure around a nuclear reactor to confine fission products that otherwise might be released to the atmosphere in the event of an accident.

Contamination: Undesired radioactive material that is deposited on the surface of or inside structures, areas, objects, or people.

Cooling tower: A heat exchanger designed to aid in the cooling of water that was used to cool exhaust steam exiting the turbines of a power plant. Cooling towers transfer exhaust heat into the air instead of into a body of water.

Core: The uranium-containing heart of a nuclear reactor, where energy is released.

Cumulative impacts: Impacts on the environment that result from the incremental impact of a proposed action when added to the impacts from other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes the other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Curie (Ci): The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion (3.7 x 1010) disintegrations per second, which is approximately the activity of 1 gram of radium. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second. It is named for Marie and Pierre Curie, who discovered radium in 1898.

Decommissioning: The process of closing down a facility followed by reducing residual radioactivity to a level that permits the release of the property for unrestricted use (see 10 CFR 20.1003).

Decontamination: The reduction or removal of contaminating radioactive material from a structure, area, object, or person. Decontamination may be accomplished by (1) treating the surface to remove or decrease the contamination, (2) letting the material stand so that the radioactivity is decreased as a result of natural radioactive decay, or (3) covering the contamination to shield or attenuate the radiation emitted (see 10 CFR 20.1003 and 20.1402).

Design basis accident: An accident postulated for the purpose of establishing functional and performance requirements for safety structures, systems, and components.

Dose: The absorbed dose, given in rads (or in SI units, grays), that represents the energy absorbed from the radiation in a gram of any material. Furthermore, the biological dose or dose equivalent, given in rem or sieverts, is a measure of the biological damage to living tissue from radiation exposure.

Dose equivalent: The product of absorbed dose in tissue multiplied by a quality factor and then sometimes multiplied by other necessary modifying factors at the location of interest. It is expressed numerically in rem or sieverts (see 10 CFR 20.1003).

Dose rate: The ionizing radiation dose delivered per unit time. For example, rem or sieverts per hour.

Effluent: A waste stream flowing into the atmosphere, surface water, groundwater, or soil. Most frequently the term applies to wastes discharged to surface waters.

Endangered Species: Animals, birds, fish, plants, or other living organisms threatened with extinction by anthropogenic (man-caused) or other natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act.

Enriched uranium: Uranium whose content of the fissile isotope uranium-235 is greater than the 0.7 percent (by weight) found in natural uranium.

Environmental Impact Statement: A document required of federal agencies by the National Environmental Policy Act for major federal actions or legislative proposals significantly affecting the environment. A tool for decision making, it describes environmental impacts of the action and alternatives to the action.

Environmental Justice: The fair treatment and meaningful involvement for all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

ENTOMB: A method of decommissioning in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombment structure is appropriately maintained and continued surveillance is carried out until the radioactivity decays to a level permitting decommissioning and ultimate unrestricted release of the property.

Exclusion area: The area surrounding the reactor where the reactor licensee has the authority to determine all activities, including exclusion or removal of personnel and property.

Fission: The splitting of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

Fission products: The nuclei (fission fragments) formed by the fission of heavy elements, plus the nuclide formed by the fission fragments' radioactive decay.

Fuel cycle: The series of steps involved in supplying fuel for nuclear power reactors. It can include mining, milling, isotopic enrichment, fabrication of fuel elements, use in a reactor, chemical reprocessing to recover the fissionable material remaining in the spent fuel, re-enrichment of the fuel material, refabrication into new fuel elements, and waste disposal.

Fusion: A reaction in which at least one heavier, more stable nucleus is produced from two lighter, less stable nuclei. Reactions of this type are responsible for enormous release of energy, as in the energy of stars, for example.

Gas-cooled reactor: A nuclear reactor in which a gas is the coolant.

Gaseous diffusion plant: A facility where uranium hexafluoride gas is filtered. Uranium-235 is separated from uranium-238, increasing the percentage of uranium-235 from 1 to about 3 percent. The process requires enormous amounts of electric power.

Half-life: The time in which one half of the atoms of a particular radioactive substance disintegrate into another nuclear form. Measured half-lives vary from millionths of a second to billions of years. Also called physical or radiological half-life.

Heat sink: Anything that absorbs heat. It is usually part of the environment, such as the air, a river, or a lake.

Heavy water moderated reactor: A reactor that uses heavy water as its moderator. Heavy water is an excellent moderator and thus permits the use of unenriched uranium as a fuel.

High-level waste: Radioactive materials at the end of a useful life cycle that should be properly disposed of, including: (1) The highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste directly in reprocessing and any solid material derived from such liquid waste that contains fission products in concentrations; (2) Irradiated reactor fuel; and (3) Other highly radioactive material that the Commission, consistent with existing law, determines by rule require permanent isolation. High-level waste (HLW) is primarily in the form of spent fuel discharged from commercial nuclear power reactors. It also includes HLW from activities and a small quantity of reprocessed commercial HLW (see 10 CFR 63.2).

In situ leach: A process using a leaching solution to extract uranium from underground ore bodies in place (in other words, in situ). The leaching agent, which contains an oxidant such as oxygen with sodium carbonate, is injected through wells into the ore body in a confined aquifer to dissolve the uranium. This solution is then pumped via other wells to the surface for processing.

Independent spent fuel storage installation or ISFSI: Independent spent fuel storage installation or ISFSI means a complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related GTCC waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage. An ISFSI which is located on the site of another facility licensed by the NRC or a facility licensed under 10 CFR Part 50 and which shares common utilities and services with that facility or is physically connected with that other facility may still be considered independent.

Leachate: Water that collects contaminants as it trickles through wastes, pesticides, or fertilizers. Leaching may occur in farming areas, feedlots, and landfills, and may result in hazardous substances entering surface water, ground water, or soil.

Light water reactor: A term used to describe reactors using ordinary water as coolant, including boiling water reactors (BWRs) and pressurized water reactors (PWRs), the most common types used in the United States.

Loss of coolant accident (LOCA): Those postulated accidents that result in a loss of reactor coolant at a rate in excess of the capability of the reactor makeup system from breaks in the reactor coolant pressure boundary, up to and including a break equivalent in size to the double-ended rupture of the largest pipe of the reactor coolant system.

Low population zone (LPZ): An area of low population density often required around a nuclear installation before it's built. The number and density of residents is of concern in emergency planning so that certain protective measures (such as notification and instructions to residents) can be accomplished in a timely manner.

Low-level waste: A general term for a wide range of wastes having low levels of radioactivity. Industries; hospitals and medical, educational, or research institutions; private or government laboratories; and nuclear fuel cycle facilities (e.g., nuclear power reactors and fuel fabrication plants) that use radioactive materials generate low-level wastes as part of their normal operations. These wastes are generated in many physical and chemical forms and levels of contamination (see 10 CFR 61.2). Low-level radioactive wastes containing source, special nuclear, or byproduct material are acceptable for disposal in a land disposal facility. For the purposes of this definition, low-level waste has the same meaning as in the Low-Level Radioactive Waste Policy Act, that is, radioactive waste not classified as high-level radioactive waste, transuranic waste, spent nuclear fuel, or byproduct material as defined in section 11e.(2) of the Atomic Energy Act (uranium or thorium tailings and waste).

Megawatt (MW): One million watts.

Megawatt hour (MWh): One million watt-hours.

Millirem: One thousandth of a rem (0.001 rem).

Mitigation: Mitigation includes: (1) avoiding an impact altogether by not taking a certain action or parts of an action; (2) minimizing impacts by limiting the degree or magnitude of an action and its implementation; (3) rectifying an impact by repairing, rehabilitating, or restoring the affected environment; (4) reducing or eliminating the impact over time by preservation and maintenance operations during the life of an action; or (5) compensating for an impact by replacing or providing substitute resources or environments.

Mixed oxide (MOX) fuel: A mixture of uranium oxide and plutonium oxide used to fuel a reactor. Mixed oxide fuel is often called "MOX." Conventional nuclear fuel is made of pure uranium oxide.

Moderator: A material, such as ordinary water, heavy water, or graphite, that is used in a reactor to slow down high-velocity neutrons, thus increasing the likelihood of fission.

Non-vital plant systems: Systems at a nuclear facility that may or may not be necessary for the operation of the facility (i.e., power production) but that would have little or no effect on public health and safety should they fail. These systems are not safety related.

Nuclear waste: A particular type of radioactive waste that is produced as part of the nuclear fuel cycle (i.e., those activities needed to produce nuclear fission, or splitting of the atom). These include extraction of uranium from ore, concentration of uranium, processing into nuclear fuel, and disposal of byproducts. Radioactive waste is a broader term that includes all waste that contains radioactivity. Residues from water treatment, contaminated equipment from oil drilling, and tailings from the processing of metals such as vanadium and copper also contain radioactivity but are not "nuclear waste" because they are produced outside of the nuclear fuel cycle. NRC generally regulates only those wastes produced in the nuclear fuel cycle (uranium mill tailings, depleted uranium, spent fuel rods, etc.).

Nuclide: A general term referring to all known isotopes, both stable (279) and unstable (about 2,700), of the chemical elements.

NUREG: NRC designation, along with an identifying number, given to reports or brochures on regulatory decisions, results of research, results of incident investigations, and other technical and administrative information.
Occupational Dose: The dose received by an individual in the course of employment in which the individual's assigned duties involve exposure to radiation or to radioactive material from licensed and unlicensed sources of radiation, whether in the possession of the licensee or other person. Occupational dose does not include dose received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive materials and released in accordance with 10 CFR 35.75, from voluntary participation in medical research programs, or as a member of the general public.

Operational mode: In a nuclear power reactor, an operational mode corresponds to any one inclusive combination of core reactivity condition, power level, and average reactor coolant temperature.

Pellet, fuel: As used in pressurized water reactors and boiling water reactors, a pellet is a small cylinder approximately 3/8-inch in diameter and 5/8-inch in length, consisting of uranium fuel in a ceramic form--uranium dioxide, UO2. Typical fuel pellet enrichments in nuclear power reactors range from 2.0 percent to 3.5 percent uranium-235.

pH: An expression of the intensity of the basic or acid condition of a liquid; may range from 0 to 14, where 0 is the most acid and 7 is neutral. Natural waters usually have a pH between 6.5 and 8.5.

Pressurized water reactor (PWR): A power reactor in which heat is transferred from the core to an exchanger by high temperature water kept under high pressure in the primary system. Steam is generated in a secondary circuit. Many reactors producing electric power are pressurized water reactors.

Probabilistic risk analysis: A systematic method for addressing the risk triplet as it relates to the performance of a complex system to understand likely outcomes, sensitivities, areas of importance, system interactions, and areas of uncertainty. The risk triplet is the set of three questions that the NRC uses to define ―risk”: (1) What can go wrong? (2) How likely is it? and (3) What are the consequences? NRC identifies important scenarios from such an assessment.

Public Dose: The dose received by a member of the public from exposure to radiation or to radioactive material released by a licensee, or to any other source of radiation under the control of a licensee. Public dose does not include occupational dose or doses received from background radiation, from any medical administration the individual has received, from exposure to individuals administered radioactive materials and released in accordance with 10 CFR 35.75, or from voluntary participation in medical research programs.

Radiation (ionizing radiation): Alpha particles, beta particles, gamma rays, x-rays, neutrons, high-speed electrons, high-speed protons, and other particles capable of producing ions.

Radiation, as used in 10 CFR Part 20, does not include non-ionizing radiation, such as radio- or microwaves, or visible, infrared, or ultraviolet light (see also 10 CFR 20.1003).

Radon: A colorless naturally occurring, radioactive, inert gas formed by radioactive decay of radium atoms in soil or rocks.

Record of decision (ROD): A concise public document that records a federal agency's decision(s) concerning a proposed action for which the agency has prepared an environmental impact statement (EIS). The ROD is prepared in accordance with the requirements of the Council on Environmental Quality NEPA regulations (40 CFR 1505.2). A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative(s), factors balanced by the agency in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and if not, why they were not.

Rem: The acronym for roentgen equivalent man is a standard unit that measures the effects of ionizing radiation on humans. The dose equivalent in rem is equal to the absorbed dose in rads multiplied by the quality factor of the type of radiation (see 10 CFR 20.1004).

Safe shutdown earthquake: Is the maximum earthquake potential for which certain structures, systems, and components, important to safety, are designed to sustain and remain functional.

SAFSTOR: A method of decommissioning in which the nuclear facility is placed and maintained in such condition that the nuclear facility can be safely stored and subsequently decontaminated to levels that permit release for unrestricted use.

Scram is the sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. May also be called a reactor trip.

Sediments: Soil, sand, and minerals washed from land into water, usually after rain. They pile up in reservoirs, rivers, and harbors, destroying fish and wildlife habitat, and clouding the water so that sunlight cannot reach aquatic plants. Careless farming, mining, and building activities will expose sediment materials, allowing them to wash off the land after rainfall.

Sievert (Sv): The international system (SI) unit for dose equivalent equal to 1 Joule/kilogram. 1 sievert = 100 rem. Named for physicist Rolf Sievert.

Siting: The process of choosing a location for a facility.

Spent fuel storage cask or cask: Spent fuel storage cask or cask means all the components and systems associated with the container in which spent fuel or other radioactive materials associated with spent fuel are stored in an Independent Spent Fuel Storage Installation.

Spent nuclear fuel: Fuel that has been removed from a nuclear reactor because it can no longer sustain power production for economic or other reasons.

Spoil: Dirt or rock removed from its original location--destroying the composition of the soil in the process--as in strip-mining, dredging, or construction.

Standard Review Plan: A document that provides guidance to the staff for reviewing an application to obtain an NRC license to construct or operate a nuclear facility or to possess or use nuclear materials.

Tailings: Residue of raw material or waste separated out during the processing of crops or mineral ores.

Terrestrial radiation: The portion of the natural background radiation that is emitted by naturally occurring radioactive materials, such as uranium, thorium, and radon in the earth.

Thermal Pollution: Discharge of heated water from industrial processes that can kill or injure aquatic organisms.

Thermal reactor: A reactor in which the fission chain reaction is sustained primarily by thermal neutrons. Most current reactors are thermal reactors

Thermal Stratification: The formation of layers of different temperatures in a lake or reservoir.

Total Effective Dose Equivalent (TEDE): The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).

Transient: a change in the reactor coolant system temperature and/or pressure due to a change in power output of the reactor. Transients can be caused (1) by adding or removing neutron poisons, (2) by that is increasing or decreasing electrical load on the turbine generator, or (3) by accident conditions.

Turbidity: A cloudy condition in water due to suspended silt or organic matter.

Uranium: A radioactive element with the atomic number 92 and, as found in natural ores, an atomic weight of approximately 238. The two principal natural isotopes are uranium-235 (0.7 percent of natural uranium), which is fissile, and uranium-238 (99.3 percent of natural uranium), which is fissionable by fast neutrons and is fertile. Natural uranium also includes a minute amount of uranium-234.

Uranium fuel fabrication facility: A facility that (1) manufactures reactor fuel containing uranium for any of the following: (i) preparation of fuel materials; (ii) formation of fuel materials into desired shapes; (iii) application of protective cladding; (iv) recovery of scrap material; and (v) storage associated with such operations; or (2) conducts research and development activities.

Uranium hexafluoride production facility: A facility that receives natural uranium in the form of ore concentrate, processes the concentrate, and converts it into uranium hexafluoride (UF6).

Waste, radioactive: Radioactive materials at the end of a useful life cycle or in a product that is no longer useful and should be properly disposed of.

Watt: An electrical unit of power. 1 watt = 1 Joule/second. It is equal to the power in a circuit in which a current of one ampere flows across a potential difference of one volt.

Yellowcake: Yellowcake is the product of the uranium extraction (milling) process; early production methods resulted in a bright yellow compound, hence the name yellowcake. The material is a mixture of uranium oxides that can vary in proportion and in color from yellow to orange to dark green (blackish) depending at which temperature the material was dried (level of hydration and impurities). Higher drying temperatures produce a darker, less soluble material. Yellowcake is commonly referred to as U3O8 and is assayed as pounds U3O8 equivalent. This fine powder is packaged in drums and sent to a conversion plant that produces uranium hexafluoride (UF6) as the next step in the manufacture of nuclear fuel.

Zooplankton: Small (often microscopic) free-floating aquatic plants or animals.

1. Introduction

1.1 Purpose and Intent of This Document

1. Introduction

This guidance provides background information for staff within the U.S. Environmental Protection Agency (EPA) who review and comment on National Environmental Policy Act (NEPA) documents prepared by the Nuclear Regulatory Commission (NRC) for new nuclear power plants (NPPs), in accordance with EPA‘s responsibilities for environmental review under §309 of the Clean Air Act. Specifically, this guidance provides information to assist EPA reviewers to:

1. Prepare scoping comments on environmental impact statements (EISs) related to NRC‘s licensing of NPPs;
2. Consider those issues most appropriate to a specific type of nuclear reactor presented in an EIS;
3. Support the development of EPA‘s comments under Clean Air Act §309; and
4. Determine the adequacy of an EIS in terms of addressing the requirements pursuant to NEPA, NRC‘s NEPA-implementing regulations, applicable case law, and the threshold of significance for individual resources.

At the beginning of each chapter in this guidance document, there is a list of questions and checklist items that identify specific aspects of the EIS that have a heightened ability to cause environmental non-compliance, and that the EPA reviewer should consider in reviewing the EIS. For topics addressed in this introductory chapter, the list is as follows:

- Has the purpose and need for the action been described?
- Has the need for power been assessed (as Chapter 8 of EIS if following NRC guidance)?
- Is a summary provided of related NEPA documents and other environmental and safety reports?
- Have all applicable regulatory requirements, permits, and agency consultations been identified in the EIS?
- In the case of a combined operating license (COL) Supplemental EIS to an existing Final EIS for an early site permit (ESP):
  - Does the design of the facility fall within the site and design parameters of the ESP?
  - Does it resolve any significant environmental issues that were deferred to the COL stage?
  - Does it identify any new and significant information affecting previous conclusions regarding impacts?

- Were impact analyses described as already existing and therefore not repeated in the COL supplement conducted fully and completely, and were their conclusions accurately brought forward?

1.1.1 National Environmental Policy Act, Council on Environmental Quality Regulations, and Clean Air Act

NEPA, as amended (42 U.S.C. 4321 et seq.), requires all federal agencies to, among other things, assess the environmental impacts of major federal actions such as issuing permits, spending federal money, or taking actions on federal lands. NEPA requires federal agencies to consider environmental impacts in making decisions and to disclose the environmental impacts to the public. In part, NEPA states that all federal agencies shall ―utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences and the environmental design arts in planning and in decision-making which may have an impact on man‘s environment" ((42 U.S.C. 4332). When an agency concludes that a proposed major federal action has the potential for causing significant environmental impacts, it is required to prepare a detailed statement, known as an EIS, analyzing those potential environmental impacts.

The President‘s Council on Environmental Quality‘s (CEQ‘s) NEPA-implementing regulations, at 40 CFR Parts 1500 – 1508, establish minimum general requirements that assure NEPA compliance. These CEQ regulations establish a multistage process that describes how an agency is to analyze and describe to the decision maker and the public any significant environmental impacts that could result from carrying out a proposed major federal action.

NEPA and the CEQ regulations require that, when a federal agency proposes legislation or another major federal action significantly affecting the quality of the human environment, the agency must prepare a detailed statement of the environmental effects and obtain comments from any other federal agency having jurisdiction by law or special expertise with respect to any environmental impact involved (42 USC 4332(C); 40 CFR 1503.1).

Section 309 of the Clean Air Act, as amended in 1970 (42 U.S.C. 7609), directs EPA to review and comment on, among other things, ―newly authorized federal projects for construction and any major federal action (other than a project for construction) of a federal agency to which 42 USC 4332(C) . . . applies" and to make those reviews available to the public. If EPA determines that any such action is environmentally unsatisfactory, the action must be referred to CEQ.

―Section 309 of the Clean Air Act places an additional requirement to review EISs upon EPA because NEPA ‗does not assure that federal environmental agencies will effectively participate in the decision-making process. It is essential that mission-oriented federal agencies have access to environmental expertise in order to give adequate consideration to environmental factors‘ " (Sen. Rept. No. 91-1196, 91 Congress, 2nd Sess. 43, 1970, as cited in EPA 2002).

Section 309 confers upon EPA broad review responsibilities for proposed major federal actions. The EPA Administrator has delegated to the Office of Federal Activities (OFA) the authority to review and comment on EISs that are multi-regional in scope and regulations proposed by other

Federal agencies for which there are national policy implications. The Administrator has delegated to the ten EPA Regional Administrators the authority to review and comment on region-specific EISs. EPA has developed a set of criteria for rating draft EISs. The rating system provides a consistent method for evaluating Draft EISs (EPA 2002). If an EIS involves significant environmental issues, the draft EIS has been rated environmentally unsatisfactory, the final EIS continues to be environmentally unsatisfactory, and every effort has been made to resolve the environmental issues, EPA may refer the Final EIS to CEQ.

EPA (OFA and regional offices) reviews approximately 500 EISs and about 2,000 other actions each year. OFA also develops guidance materials, provides NEPA and §309 training courses, and promotes coordination between EPA offices and other federal agencies.

1.1.2 The Energy Policy Act

The Energy Policy Act of 2005 (P.L. 109-58), signed by President George W. Bush on August 8, 2005, was prompted by rising energy prices and growing dependence on foreign oil. The ―energy law was shaped by competing concerns about energy security, environmental quality, and economic growth" (CRS 2006, page 1). The major provisions include tax incentives for domestic energy production and energy efficiency, a mandate to double the nation‘s use of biofuels, repeal of restrictions on interstate utility holding companies, faster procedures for energy production on federal lands, and authorization of numerous federal energy research and development programs (CRS 2006, pages 1-5).

Title VI of the Act, ―Nuclear Matters," contains most of its nuclear-specific provisions. These provisions are briefly summarized below, with emphasis on those related to new NPPs:

- Subtitle A, The Price-Anderson Act Amendments: Limitations on ―liability for damages to the general public from nuclear incidents is extended through 2025 for new NPPs and new Department of Energy (DOE) nuclear contracts. The extension makes relatively few changes in the longstanding Price-Anderson system, except that the maximum annual accident assessment on each reactor is raised from $10 million to $15 million and is subjected for the first time to an inflation adjustment. Special treatment is also provided for modular reactors. The renewal of Price-Anderson was widely considered to be a prerequisite for building the new NPPs that are encouraged elsewhere in the Act" (CRS 2006, page 38).

- Subtitle B, General Nuclear Matters: Construction of new NPPs is encouraged by authorizing payments to compensate for reactor licensing delays. (Some existing NPPs experienced long delays due to litigation before they received their operating licenses and could begin to recover construction and related costs.) Subtitle B ―clarifies when the 40-year period for reactor operating licenses takes effect, and eliminates antitrust reviews of reactor license applications. Exports of weapons-usable highly enriched uranium for medical isotope production are exempted from restrictions designed to speed conversion to low-enriched uranium. Ensuring adequate staffing at NRC is addressed, with incentives for both students and retirees to work at the agency. User fees that fund 90% of NRC‘s costs are extended permanently" (CRS 2006, page 40).

- Subtitle C, Next Generation Nuclear Plant Project: “DOE is authorized to build and operate a prototype Next Generation [NPP] at Idaho National Laboratory, . . . which must produce electricity, hydrogen, or both. [The plant] is to use one of the advanced reactor concepts from DOE‘s Generation IV Nuclear Energy Systems Initiative” (CRS 2006, page 44).

- Subtitle D, Nuclear Security: A variety of provisions are specified “to improve the security of [NPPs] and nuclear materials.” NRC was required “to revise the ‘design basis threat‘ that [NPP] security forces must be able to overcome. . . [E]ach [NPP] must undergo force-on-force security evaluations at least every three years. . .” (CRS 2006, page 46). Each NRC region must have a federal security coordinator. “Other provisions require tracking of radiation sources, authorize [NPP] . . . security forces [to use firearms], and require NRC [to consult] with the Department of Homeland Security on proposed nuclear facility locations” (CRS 2006, page 46).

The Energy Policy Act of 2005 contains numerous other incentives for new NPPs under its other titles, including incentives for innovative technologies, a tax credit for production from advanced nuclear power facilities, loan guarantees for up to 80 percent of eligible project costs, numerous research and development programs related to existing and advanced reactors, and provisions for education of future specialists (DOE 2008).

1.1.3 NRC Authorities Related to NPPs

The Energy Reorganization Act of 1974 and its later amendment established the Nuclear Regulatory Commission, assigning to NRC authority for the safety regulation of the civilian uses of nuclear materials and providing protections for employees who raise nuclear safety concerns.

The Atomic Energy Act of 1954, as amended, requires that civilian uses of nuclear materials and facilities be licensed, authority for which was assigned to NRC by the 1974 Energy Reorganization Act.

Under NEPA, NRC is responsible for assessing the environmental impacts of major federal actions, which includes issuing licenses to applicants for construction and operation of an NPP.

1.1.4 EPA Authorities Related to NPPs

Section 309 of the Clean Air Act directs EPA to review and comment on EISs for major federal actions, including licensing the construction and operation of NPPs, as described in Section 1.1.1 of this guidance document. Section 112 of the Clean Air Act provides EPA the authority to list hazardous air pollutants, or HAPs, and to develop and enforce emission limits for each of them. Section 112(a) introduced the concept of "ample margin of safety to protect public health" in setting these limits. The limits are referred to as "National Emission Standards for Hazardous Air Pollutants" or NESHAPs. Section 502 of the Clean Air Act, responsibility for which may be delegated to a state, requires issuance of an operating permit for nonradiological air emissions.

As authorized by the Clean Water Act, EPA regulates thermal discharges (under Section 316(a)); cooling water intake location, design, construction, and capacity (under Section 316(b)); permits for discharges under the National Pollutant Discharge Elimination System (NPDES) (under Section 401); storm water discharges (under Section 402); and, with the U.S. Army Corps of Engineers, regulates dredging, filling, and wetlands impacts (under Section 404).

The Safe Drinking Water Act of 1974 (SDWA) transferred responsibility for regulation of drinking water to the EPA and called on the EPA to take a number of steps to protect the quality of the nation‘s drinking water supplies. Section 1424(e) of the SDWA established a ―Sole Source Aquifer Program.” EPA was authorized to identify aquifers that are the only or principal source of drinking water for an area. The program also calls for EPA to review all federally funded projects planned for the area.

The Atomic Energy Act, as amended in 1954, established the Atomic Energy Commission (AEC) to promote the "utilization of atomic energy for peaceful purposes to the maximum extent consistent with the common defense and security and with the health and safety of the public." When EPA was formed, the AEC's authority to issue generally applicable environmental radiation standards was transferred to EPA. Other federal and state organizations must follow these standards when developing requirements for their areas of radiation protection.

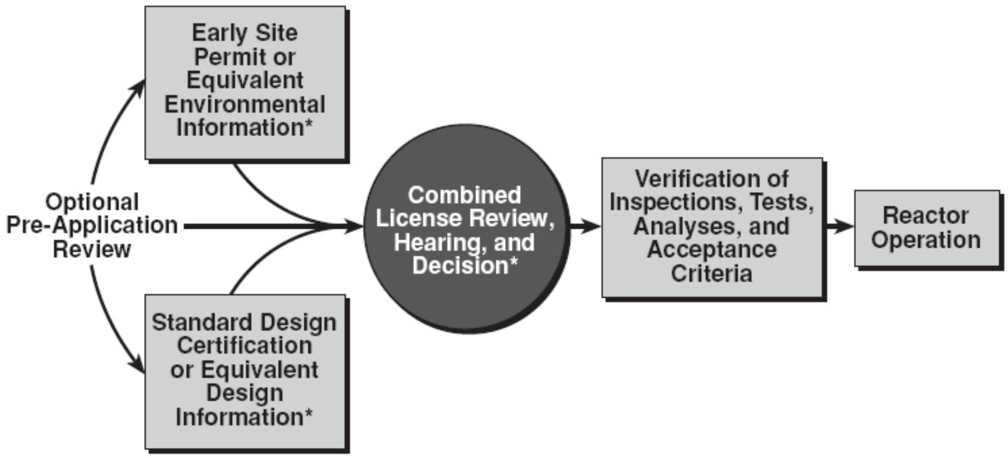
1.2 NPP Licensing and NEPA

1.2.1 Overview of the NPP Licensing Process

Prior to 1989, NRC licensed NPPs under a two-step process, requiring both a construction permit (CP) and an operating license (OL). In 1989, NRC finalized regulations establishing an alternative licensing process that combined a construction permit and an operating license, with certain conditions, into a combined license (COL). NRC also established two new licensing alternatives in 1989: early site permits (ESPs), which allow an applicant to obtain approval for a reactor site and save it for future use, and standard design certifications where NRC pre-approves standard plant designs, which reduces licensing uncertainty by resolving design issues (NRC 2004a). This section summarizes the requirements for COLs and ESPs, the licenses sought for new reactors, and describes the design certification process.

―A COL application can reference an ESP, a standard design certification, both, or neither. If an application does not reference an ESP and/or a standard design certification, the applicant must provide an equivalent level of information in the COL application” (NRC 2004a). Figure 1-1 shows the relationships between COLs, ESPs, and standard design certifications.

Figure 1-1. Relationships between Combined Licenses, Early Site Permits, and Standard Design Certifications



*See detailed requirements in the following sections.

Source: NRC 2004a

1.2.1.1 Early Site Permits

NRC can issue an ESP to approve one or more sites for one or more nuclear power facilities separate from an application for a CP or COL. The ESP process resolves site safety, environmental protection, and emergency preparedness issues without requiring that an applicant specify the NPP design. The ESP application addresses the safety and environmental characteristics of the site itself, and evaluates potential physical obstacles to developing an acceptable emergency plan (NRC 2005). ESPs are good for 10 to 20 years and can be renewed for an additional 10 to 20 years (NRC 2004b).

An ESP is a partial CP and therefore is subject to all procedural requirements in 10 CFR Part 2 that are applicable to CPs. Applications for ESPs are reviewed according to the standards in 10 CFR Parts 50 and 100 as they apply to applications for CPs for NPPs. The requirements and procedures applicable to NRC issuance of an ESP are specified in 10 CFR Part 52, Subpart A. Applications must include a site safety analysis report, a complete environmental report, and emergency plans (10 CFR 52.17). 10 CFR Part 51 contains NRC's environmental regulations relevant to licensing an NPP.

1.2.1.2 Combined Operating Licenses

A COL, when issued, is authorization from NRC to construct and operate, after certain conditions are met, an NPP at a specific site and in accordance with laws and regulations (NRC 2005). The objective of the COL is to resolve safety and environmental issues before authorizing construction. The COL process is expected to prevent regulatory uncertainty and reduce the financial risk to licensees. The COL licensing process is further expedited by incorporating ESPs and standard design certifications.

The requirements and procedures applicable to NRC issuance of a COL are specified in 10 CFR Part 52, Subpart C. The COL application must contain essentially the same information required for CPs and OLs issued under 10 CFR Part 50, including a final safety analysis report (FSAR); inspections, test, analysis, and acceptance criteria (ITAAC) (depending on ITAAC inclusion with any ESP and consistent with any ITAAC associated with a certified design, if applicable); a completed environmental report; and, if applicable, information on allowed site preparation-related activities that may precede issuance of the COL.

The NRC staff has developed guidance for COL applicants in the form of Regulatory Guide 1.206, ―Combined License Applications for Nuclear Power Plants” (NRC 2007a). This guidance breaks the requirements into steps that aid compliance with the regulations.

The following general regulatory provisions apply to filing a COL application:

- Any person except one excluded by 10 CFR 50.38 ―Ineligibility of certain applicants” may file an application for a combined license for a nuclear power facility with the Director of NRC‘s Office of New Reactors (NRC 2007a).

- The application must comply with the applicable filing requirements of 10 CFR 52.3 ―Written communications” and 10 CFR 50.30 ―Filing of application; oath or affirmation” (10 CFR 52.75(b)).

- The application must contain all of the information required by 10 CFR 50.33 ―Contents of applications; general information” (10 CFR 52.77).

The COL application should consist of the items listed below (NRC 2007a):

- <u>Transmittal Letter</u>: The transmittal letter includes an oath and affirmation.

- <u>Final Safety Analysis Report (FSAR):</u> The technical information required in the FSAR is described in 10 CFR 52.79. In sum, the FSAR ―describes the facility, presents the design bases and the limits on its operation, and presents a safety analysis of the structures, systems, and components of the facility as a whole” (10 CFR 52.79).

- <u>Inspections, Test, Analysis, and Acceptance Criteria (ITAAC):</u> The requirements in 10 CFR 52.80 specify that a COL application must include ―the proposed inspections, tests, and analyses (including those that apply to emergency planning) that the licensee shall perform and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria are met, the facility has been constructed and will operate in conformity with the [COL], the provisions of the [Atomic Energy] Act, and the [NRC] regulations” (10 CFR 52.80).

- <u>Probabilistic Risk Assessment (PRA)</u>: RG 1.206 states that ―In accordance with 10 CFR Part 52, a COL application is required to contain a description of the plant-specific PRA and its results.” 10 CFR Part 52 requires the applicant to provide a description of the plant-specific PRA and its results within its FSAR (10 CFR 52.79(a)(46)).

- <u>Environmental Report:</u> 10 CFR 52.80(b) requires an environmental report to be submitted with an application for a COL. The environmental report, with contents specified in 10 CFR 51.45 through 51.52, contains a description of the proposed action, a statement of its purposes, a description of the affected environment, alternatives, environmental impacts and other information required for compliance with §102(2) of NEPA. If an environmental report was submitted to support an ESP application for the same proposal, the COL environmental report does not need to include previously supplied information and analyses, nor information that was resolved in the ESP EIS; however, it will need to demonstrate the continuing applicability of the information and resolve any issues that were deferred to the COL stage (10 CFR 51.50(c)(1)).

- <u>Security Plan:</u> Under 10 CFR 52.79(a)(35), a physical security plan is a component of the technical information required to be included in the FSAR. The COL application should indicate that a security plan has been prepared and submitted separately to the NRC. The security plan would describe the elements of the COL applicant‘s individual security plans (such as plans for physical security, training and qualification, and safeguards contingency). The security plan should also describe the site security provisions proposed for the construction phase (NRC 2007a).

- <u>General and Financial Information:</u> 10 CFR 52.77 states that the COL application must contain the general and financial information specified in 10 CFR 50.33. The financial information is required to demonstrate ―that the applicant possesses or has reasonable assurance of obtaining the funds necessary to cover estimated construction costs and related fuel cycle costs" and operational costs (10 CFR 50.33(f)(2)).

- <u>Quality Assurance (QA) Program Description</u>: An applicant is responsible for establishing and implementing a QA program applicable to activities during design, fabrication, construction, testing, and operation of the nuclear power plant. Appendix B to 10 CFR Part 50 sets out the requirements for QA programs. The QA program description must be included in the FSAR (10 CFR 52.79(a)(25)).

The specific information required for each of these items depends upon the documents incorporated by reference into the application. As previously stated, an application for a COL may reference a standard design certification, an ESP, both, or neither. In general, NRC (2004a, pages 13-14) summarizes the differing requirements as follows:

- If the application references a standard design certification, the applicant must perform the ITAAC for the certified design and the site-specific design features.

- If the application does not reference a standard design certification, the application must include complete design information, including all the details that are required for a standard design certification. [This includes the equivalent ITAAC normally associated with certified designs and the site-specific design portions (not certified) of the facility.]

- If the application references an ESP, the design of the plant must be demonstrated to be compatible with the ESP and issues that were not resolved during the ESP process must be addressed, such as the need for power from the proposed plant.

- If the application does not reference an ESP, the applicant must provide the site information that would be included in an ESP [application and] include a complete emergency plan.

1.2.2 NEPA Documents for NPPs

An EIS is required for any license issued by NRC to site, construct, or operate a new NPP (10 CFR 51.20(b)). The scope of EIS may be for a limited work authorization (LWA)/construction permit, early site permit (ESP), or a combined operating license (COL). An EIS for a COL could, in turn, be prepared as a Supplemental EIS to a Final EIS for an ESP. NEPA documents for standard design certification or for a manufactured reactor may also be referenced. In the case of a COL, the Supplemental EIS to the ESP Final EIS must include information to demonstrate that the design of the facility falls within the site characteristics and design parameters specified in the ESP (where applicable); information to resolve any significant environmental issue that was not resolved in the ESP proceeding; any new and significant information for issues related to the impacts of construction and operation of the facility that were resolved in the ESP proceeding; and a description of the process used to identify new and significant information regarding previous conclusions in the ESP EIS. In the case of a standard design certification or manufactured reactor, if the environmental review for either is referenced, the COL EIS must contain information to demonstrate that the site characteristics for the COL fall within the site parameters in the design certification NEPA document (10 CFR 51.49 and 10 CFR 51.50).

For either an ESP or a COL for a new NPP, the applicant submits an environmental report to NRC and NRC prepares an EIS. For a COL application that references an ESP, NRC develops a Supplemental EIS to the Final EIS for the ESP (10 CFR 51.92(b)). Although additional scoping is not required in this case, the supplemental EIS for the COL will be published for a 45-day public comment period (10 CFR 51.92 (d), (f)).

Information and analyses developed for other aspects of the licensing process may be incorporated by reference into an ESP or COL EIS, consistent with CEQ‘s regulations at 40 CFR 1502.21. The EIS should include the conclusions contained in those analyses, and should clearly reference the documents and sources.

In many cases, the proposed plant may be co-located with an existing nuclear plant/unit that has been the subject of previous environmental reviews, such as a Supplemental EIS associated with relicensing an existing plant.

A COL EIS (or COL supplement to the ESP Final EIS) should fully characterize the potential for environmental impacts, and, unless otherwise acknowledged, described in detail, and analyzed, (1) the details of the proposed action and the development of the range of alternatives should be consistent between the ESP and COL NEPA analyses, (2) impact analyses deferred to the COL stage by an earlier ESP EIS should have been completed, and (3) impact analyses described as already existing in the ESP EIS and therefore not repeated in the COL supplement should have been fully and completely conducted, and their conclusions should be accurately brought forward.

1.2.3 Pre-Construction Activities are Evaluated for Cumulative Impacts Only

NRC‘s authority (and corresponding NEPA review) only extends to ―activities that have a reasonable nexus to radiological health and safety and/or common defense and security for which regulatory oversight is necessary and/or most effective in ensuring reasonable assurance of adequate protection to public health and safety” (NRC 2007b). NRC regulations acknowledge that certain pre-construction activities for NPPs could commence before a CP or COL is issued, and that these are outside of NRC‘s regulatory authority. NRC defines the following activities as explicitly not part of construction, and therefore not within their authority (NRC 2007b):

> (i) Changes for temporary use of the land for public recreational purposes;
> (ii) Site exploration, including necessary borings to determine foundation conditions or other preconstruction monitoring to establish background information related to the suitability of the site, the environmental impacts of construction or operation, or the protection of environmental values;
> (iii) Preparation of a site for construction of a facility, including clearing of the site, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas;
> (iv) Erection of fences and other access control measures;
> (v) Excavation;
> (vi) Erection of support buildings (such as, construction equipment storage sheds, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings) for use in connection with the construction of the facility;
> (vii) Building of service facilities, such as paved roads, parking lots, railroad spurs, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and transmission lines;
> (viii) Procurement or fabrication of components or portions of the proposed facility occurring at other than the final, in-place location at the facility;
> (ix) Manufacture of a nuclear power reactor under a manufacturing license under subpart F of part 52 of this chapter to be installed at the proposed site and to be part of the proposed facility; or
> (x) With respect to production or utilization facilities, other than testing facilities and nuclear power plants, required to be licensed under Section 104.a or Section 104.c of the Act, the erection of buildings which will be used for activities other than operation of a facility and which may also be used to house a facility (e.g., the construction of a college laboratory building with space for installation of a training reactor.

Therefore, some pre-construction activities outside of NRC‘s authority may be excluded from the analysis in the EIS, but EPA reviewers should find that the cumulative effects analysis for the construction that is proposed in the EIS considers the cumulative impacts of any such pre-construction activities that were outside of NRC‘s purview. To re-state this point, any activities that are considered ―pre-construction” will only be evaluated in the EIS for their cumulative impacts, and will not be assessed in terms of direct or indirect environmental impacts they may cause, as NRC has determined that they are not within NRC‘s regulatory authority.

1.2.4 Limited Work Authorizations

Within the scope of their authority, NRC may issue a limited work authorization (LWA) allowing an applicant to perform the driving of piles; subsurface preparation; placement of backfill, concrete, or permanent retaining walls within an excavation; or installation of the foundation, including placement of concrete; any of which are for a structure, system, or component of the facility for which either a CP or COL is otherwise required. An applicant may apply for an LWA as part of an application for a CP or COL. An LWA application must include a safety analysis; an environmental report; and a plan for redress of the site to address the placement of piles and ensure removal of the foundation, which are the only activities that may be accomplished under an LWA, in the event that construction is terminated by the applicant or denied by NRC (10 CFR 50.10 (d)). NRC will complete a Final EIS on the proposal before issuing the LWA (10 CFR 50.10 (e)). If included in an application for a CP or COL for which an EIS is prepared, EPA reviewers should be able to identify that NRC has included these activities within the construction activities for which direct, indirect, and cumulative impacts are analyzed.

1.3 Overview of EPA Environmental Review Process

As stated in Section 1.1.1, OFA has developed a set of criteria for rating Draft EISs. The rating system synthesizes and categorizes EPA‘s overall concerns with the proposed action. When transmitting the rating to the lead agency, EPA makes recommendations for improving the Draft EIS and, if appropriate, reducing the environmental impact of the proposed action. EPA reviews and comments in writing on all Draft EISs officially filed with the Agency, as required by Clean Air Act §309, provides a rating of the Draft EIS that summarizes EPA's level of concern, and meets with the lead agency to resolve significant issues, as necessary (EPA 1984, Chapter 4). The rating system, as laid out in EPA‘s ―Policy and Procedures for the Review of Federal Actions Impacting the Environment” (EPA 1984, referred to as the 309 Manual) is presented in Figure 1-2.

The 309 Manual provides guidance on commenting under NEPA and Clean Air Act §309. In addition to giving a rating, comment letters on the Draft EIS should, if appropriate, recommend consideration of mitigation to avoid or minimize unmitigated environmental impacts, assist agencies in avoiding possible violations of national environmental standards, suggest additional alternatives, address the purpose and need for the project, and, in certain cases, address specific compliance issues associated with the Clean Water Act and Safe Drinking Water Act.

EPA conducts detailed reviews of those Final EISs for which significant issues were raised by EPA at the Draft EIS stage (EPA 1984, Chapter 6). Such Final EISs are checked to determine whether the statement adequately resolves any issues that EPA identified in the Draft EIS, or whether there has been a substantive change in the proposal. EPA reviews in detail and submits comments on Final EISs for those actions rated with ―environmental objections” (EO) or ―environmentally unsatisfactory” (EU) at the draft stage (see Figure 1-2), or if EPA‘s Environmental Review Coordinator (ERC) determines that conditions warrant it. For the purposes of this guidance, the ERC is the OFA NEPA Compliance Division Director. OFA assigns federal agency liaison staff to coordinate with the headquarters office of the NRC.

1.4 Audience

This guidance has been developed for EPA reviewers of EISs prepared by NRC for new NPPs.

1.5 Interagency Coordination and Public Involvement

Construction and operation of a nuclear power plant may require permits and approvals in addition to the NRC license itself, such as construction permits, National Pollutant Discharge Elimination System permits, U.S. Army Corps of Engineers-issued Clean Water Act §404 permits, and others. The presence of environmentally sensitive resources could trigger an environmental review under another law, a regulation, or an executive order, such as consultation for compliance with §7 of the Endangered Species Act or with §106 of the National Historical Preservation Act. In accordance with the CEQ NEPA regulations, any required state-level NEPA-equivalent review should be coordinated with the NRC NEPA review to the extent possible. Obtaining water rights for cooling and other facility water needs also could involve similar coordination. Federal, state, or local permits may be required (an overview of potential permit needs is presented in Appendix A).

Public meetings, including scoping meetings, are not explicitly required by NRC's NEPA-implementing regulations. However, prior to developing an ESP or COL Draft EIS, NRC generally holds at least one public scoping meeting to gather input regarding the issues and alternatives to be analyzed in the document. When the Draft EIS is published for comment, NRC typically holds one or more public meetings to brief the community on the findings and to solicit comments on the Draft EIS. In addition to these public involvement activities typical of all agencies' NEPA processes, public meetings between the NRC technical staff and applicants or licensees are open for interested members of the public to attend as observers as described in "Commission Policy Statement on Staff Meetings Open to the Public" (NRC 2000a).

In its 2004 policy statement on environmental justice, NRC asserted that review of available demographic data and the existing NRC NEPA scoping procedures (10 CFR 51.29) ensure "that minority and low-income communities, including transient populations, affected by the proposed action are not overlooked in assessing the potential for significant impacts unique to those communities" (NRC 2004c). There are no agency requirements or recommendations for scoping or special outreach activities specifically addressing environmental justice issues.

1.6 Description of Purpose and Need

An NPP EIS must describe the purpose of and need for the proposed action (10 CFR 51, Appendix A). The statement of an agency's underlying purpose and need is critical to identifying the range of reasonable alternatives. Therefore, it should always be reviewed critically in relation to the alternatives analyzed in the EIS to ensure that an adequate and reasonable range of alternatives has been considered.

According to EPA's "Policy and Procedures for the Review of Federal Actions Impacting the Environment," referred to as the 309 Manual (EPA 1984, as updated by EPA 2007), EPA

Figure 1-2

EPA Rating System

A. Rating the Environmental Impact of the Action.

1. LO (Lack of Objections). The review has not identified any potential environmental impacts requiring substantive changes to the preferred alternative. The review may have disclosed opportunities for application of mitigation measures that could be accomplished with no more than minor changes to the proposed action.

2. EC (Environmental Concerns). The review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the preferred alternative or application of mitigation measures that can reduce the environmental impact.

3. EO (Environmental Objections). The review has identified significant environmental impacts that should be avoided in order to adequately protect the environment. Corrective measures may require substantial changes to the preferred alternative or consideration of some other project alternative (including the no action alternative or a new alternative). The basis for environmental Objections can include situations:

1. Where an action might violate or be inconsistent with achievement or maintenance of a national environmental standard;

2. Where the Federal agency violates its own substantive environmental requirements that relate to EPA's areas of jurisdiction or expertise;

3. Where there is a violation of an EPA policy declaration;

4. Where there are no applicable standards or where applicable standards will not be violated but there is potential for significant environmental degradation that could be corrected by project modification or other feasible alternatives; or

5. Where proceeding with the proposed action would set a precedent for future actions that collectively could result in significant environmental impacts.

4. EU (Environmentally Unsatisfactory). The review has identified adverse environmental impacts that are of sufficient magnitude that EPA believes the proposed action must not proceed as proposed. The basis for an environmentally unsatisfactory determination consists of identification of environmentally objectionable impacts as defined above and one or more of the following conditions:

1. The potential violation of or inconsistency with a national environmental standard is substantive and/or will occur on a long-term basis;

2. There are no applicable standards but the severity, duration, or geographical scope of the impacts associated with the proposed action warrant special attention; or

3. The potential environmental impacts resulting from the proposed action are of national importance because of the threat to national environmental resources or to environmental policies.

B. Adequacy of the Impact Statement.

1 (Adequate). The draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action. No further analysis or data collection is necessary, but the reviewer may suggest the addition of clarifying language or information.

2 (Insufficient Information). The draft EIS does not contain sufficient information to fully assess environmental impacts that should be avoided in order to fully protect the environment, or the reviewer has identified new reasonably available alternatives that are within the spectrum of alternatives analyzed in the draft EIS, which could reduce the environmental impacts of the proposal. The identified additional information, data, analyses, or discussion should be included in the final EIS.

3 (Inadequate). The draft EIS does not adequately assess the potentially significant environmental impacts of the proposal, or the reviewer has identified new, reasonably available, alternatives, that are outside of the spectrum of alternatives analyzed in the draft EIS, which should be analyzed in order to reduce the potentially significant environmental impacts. The identified additional information, data, analyses, or discussions are of such a magnitude that they should have full public review at a draft stage. This rating indicates EPA's belief that the draft EIS does not meet the purposes of NEPA and/or the Section 309 review, and thus should be formally revised and made available for public comment in a supplemental or revised draft EIS.

Source: EPA 1984

comment letters may need to address purpose and need if a detailed review of alternatives is required:

> If a detailed review of alternatives is required, the reviewer may have to address the purpose of and need for the proposed action in order to determine to what degree an alternative would meet project objectives. In these cases, the reviewer may comment on the technical adequacy and accuracy of the EIS's methods for estimating the need for the proposed action in cases where this affects the definition of reasonable and feasible alternatives. Within the context of reviewing purpose and need, the EPA may also comment on the economic justification of the project, and the relationship between the lead agency's economic analysis and any unquantified environmental impacts, values, and amenities. The comments may also address the technical validity and adequacy of the supporting data for the EIS's economic analyses [from Chapter 4.3.E of EPA 1984].

The purpose of licensing new NPP construction is likely to be fairly standardized across all NRC EISs, because all are proposed to meet power generation needs.

NRC‘s ―Environmental Standard Review Plan for Environmental Reviews for Nuclear Power Plants" (NRC 2000b; also frequently referenced by its agency document designation NUREG 1555, and being updated (see NRC 2007c)), does not call for a separate major chapter presenting the purpose and need for the proposed NPP. Recent ESP EISs have included a subsection on purpose and need within the introductory chapter.

A specific aspect of the purpose and need topic for a new NPP is the need for power. NRC provides specific guidance for NRC staff in assessing the need for power and the aspects of this issue to be covered in an NPP EIS, which typically is presented as Chapter 8 of an NPP EIS. NRC describes the power system, power demand (including power and energy requirements, as well as factors affecting the growth of demand), and power supply, and presents an assessment of the need for power (NRC 2000b, Section 8.0).

An EIS for a COL should include an assessment of the need for power, which is an important input for the alternatives analysis. An EIS for an ESP need not include an assessment of the need for power unless the applicant elects to address the need for power in its application. The alternatives should include the no action alternative, alternative sites, and alternative plant systems for functions such as heat dissipation and water circulation. The latest draft revision to NRC‘s Standard Review Plan for the Environmental Reviews for Nuclear Power Plants (NRC 2007c, Section 9.2), which is available for both use and comment, does not call for evaluation of energy alternatives for an ESP EIS.

1.7 Organization of this Document

The sequence of sections within this guidance is generally consistent with the sequence of topics as they would appear in an NPP EIS that follows the latest revision to NRC‘s guidance in NUREG 1555 (NRC 2000b, NRC 2007c). However, the contents of an EIS will depend upon whether the EIS is for an ESP, a COL with an existing ESP, a COL without an existing ESP, an OL, or a CP.

This guidance document contains the following sections:

1. Introduction
2. Plant Description
3. Environmental Description (Affected Environment)
4. Site Layout and Plant Parameter Envelope
5. Construction Impacts
6. Operational Impacts
7. Transportation of Radioactive Materials
8. Nuclear Fuel Cycle
9. Decontamination and Decommissioning
10. Mitigation Actions and Requirements
11. Cumulative Impacts
12. Irreversible and Irretrievable Commitment of Resources
13. Short-Term Uses vs. Long-Term Productivity
14. Alternatives
15. Comparison of Proposed Action and Alternatives
16. List of Contacts (EPA associate reviewers/offices, HQ & Regional)
17. Annotated Bibliography

Appendices A through J

The Appendices to this guidance contain ten sections that are referenced throughout this document. References are listed at the end of each chapter, and provide the web page locations for many documents that are available on the Internet.

Section 1 References

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

CRS 2006: Congressional Research Service Report for Congress--Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions. March 8, 2006. http://ncseonline.org/NLE/CRSreports/06Apr/RL33302.pdf

DOE 2008: U.S. Department of Energy, Office of Nuclear Energy. New Plant Incentives within the Energy Policy Act of 2005 (EPACT 2005). Website. http://www.ne.doe.gov/energyPolicyAct2005/neEPACT2a.html

EPA 1984: U.S. Environmental Protection Agency. Policy and Procedures for the Review of Federal Actions Impacting the Environment. October 3, 1984. http://www.epa.gov/compliance/resources/policies/nepa/nepa_policies_procedures.pdf

EPA 2002: U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance. EPA's Section 309 Review: The Clean Air Act and NEPA, Quick Reference Brochure. May 2002.

EPA 2007: U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance. Memorandum: Errata for the Policy and Procedures for the Review of Federal Actions Impacting the Environment. From Anne Norton Miller, Director, OFA. July 19, 2007.

NRC 2000a: U.S. Nuclear Regulatory Commission. Staff Meetings Open to the Public: Final Policy Statement. 65 Federal Register 183:56964-56966. September 20, 2000.

NRC 2000b: U.S. Nuclear Regulatory Commission. NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2004a: U.S. Nuclear Regulatory Commission, Office of Public Affairs. Nuclear Power Plant Licensing Process, NUREG/BR-0298, Rev. 2. http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0298/br0298r2.pdf

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NRC 2004c: U.S. Nuclear Regulatory Commission. Policy statement on the treatment of environmental justice matters in NRC regulatory and licensing actions. August 24, 2004.

http://a257.g.akamaitech.net/7/257/2422/06jun20041800/edocket.access.gpo.gov/2004/pdf/04-19305.pdf

NRC 2005: U.S. Nuclear Regulatory Commission, Office of Public Affairs. Nuclear Power Plant Licensing Process Backgrounder. July 2005. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/licensing-process-bg.pdf

NRC 2007a: U.S. Nuclear Regulatory Commission. Regulatory Guide 1.206 Combined License Applications for Nuclear Power Plants (LWR Edition). June 20, 2007. http://www.nrc.gov/reading-rm/doc-collections/reg-guides/power-reactors/active/01-206/

NRC 2007b: U.S. Nuclear Regulatory Commission. Limited Work Authorizations for Nuclear Power Plants; Final Rule. 72 Federal Register 57416-57447 (October 9, 2007).

NRC 2007c: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555, draft revisions. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html

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2. Plant Description

2. Plant Description

- Does the EIS fully describe all aspects of plant design, construction, and operation?
- Does the EIS clearly breakout the pre-construction activities (evaluated only in terms of cumulative impacts) from those that are part of full plant construction and operation, so that the impacts of each can be clearly differentiated?
- Does it fully describe the cooling system, including the following aspects?
  - operational modes to address potential impacts of heat dissipation
  - projected water needs and potential impacts to downstream water use/consumption
  - information on use of biocides or other chemicals anticipated to be used to control organisms in the cooling system
  - information on water quality permits and current status
  - thermal aspects of the cooling system
  - design details of the heat dissipation system components
- Does the EIS describe the water treatment that will be required for plant operation, including pre-use treatment of cooling water and treatment of plant waste streams?
- Does the EIS include a full description of the radioactive waste management system, nonradioactive waste systems, plant effluents (containing chemicals or biocides), sanitary system effluents, and other effluents?

Nuclear power plants generate electricity by using the energy released from nuclear fission. During fission, uranium-235 atoms absorb neutrons, become unstable, and then split into fission products (atoms of lighter elements) while releasing energy in the form of heat and free neutrons. The released neutrons induce fission in other uranium-235 atoms, resulting in a self-sustaining chain reaction. Water heated by the released energy creates steam, which turns turbines to generate electricity, just as fossil or other fuel types heat water to steam for the turbines of non-nuclear electric power plants. Different reactor designs use variations in the way the water and steam are circulated, how the fuel is handled and cooled, and other details.

Reactors currently in commercial use in the U.S. fall into two main categories of reactor designs: boiling water reactors (BWRs) and pressurized water reactors (PWRs). Additional designs that do not fit into these categories are in various conceptual and planning stages. BWRs, PWRs, and other designs are described in general terms below. Appendices B through D contain the following additional information on new reactor designs:

- Appendix B: New Nuclear Power Plant Design Certification Status
- Appendix C: Design Profile / Technical Summary of Reactor System Designs
- Appendix D: Environmental Attributes of the Nuclear Power Plant Designs

The EIS should include a full plant description, including the number and type of reactors (design, vendor, architecture-engineering firm, contractor, fuel assembly description, total quantities of uranium, and percentage of uranium enrichment), engineered safety features, highest anticipated gross thermal megawatt output, and net electrical output. Reference should be made to the certified design selected (and associated NEPA documentation) for the site/plant and whether additional adjustments were needed to account for site-specific conditions such as seismic/vibratory ground motion spectra.

The EIS should include a full description of the cooling system, including the plant water use (maximum water consumption) requirements, water intake type, heat dissipation type (such as cooling towers), discharge type, and source of cooling water. As background, nuclear power plants withdraw large amounts of mainly surface water to meet a variety of plant needs. The predominant water use is for removing excess heat generated in the reactor by condenser cooling. The options could include once-through cooling system, closed cycle cooling system (with cooling tower), and cooling ponds. The quantity of water used for condenser cooling is a function of several factors, including the capacity rating of the plant and the increase in cooling water temperature from the intake to the discharge. The larger the plant, the greater the quantity of waste heat to be dissipated, and the greater the quantity of cooling water required. Most of the plants are expected to use closed-cycle systems with cooling towers, although some may use a cooling lake or canals for transferring heat to the atmosphere. In closed-cycle systems, the cooling water is recirculated through the condenser after the waste heat is removed by dissipation to the atmosphere, usually by recirculating the water through large cooling towers. Recirculating cooling systems consist of either natural draft of mechanical draft cooling towers, cooling ponds, cooling lakes, or cooling canals. Because the predominant cooling mechanism associated with closed-cycle systems is evaporation, most of the water used for cooling is consumed and is not returned to a water source. Cooling system water must be physically or chemically conditioned or treated, depending on the quality of the source water. Plant waste streams also require treatment before permitted discharge or packaging for disposal.

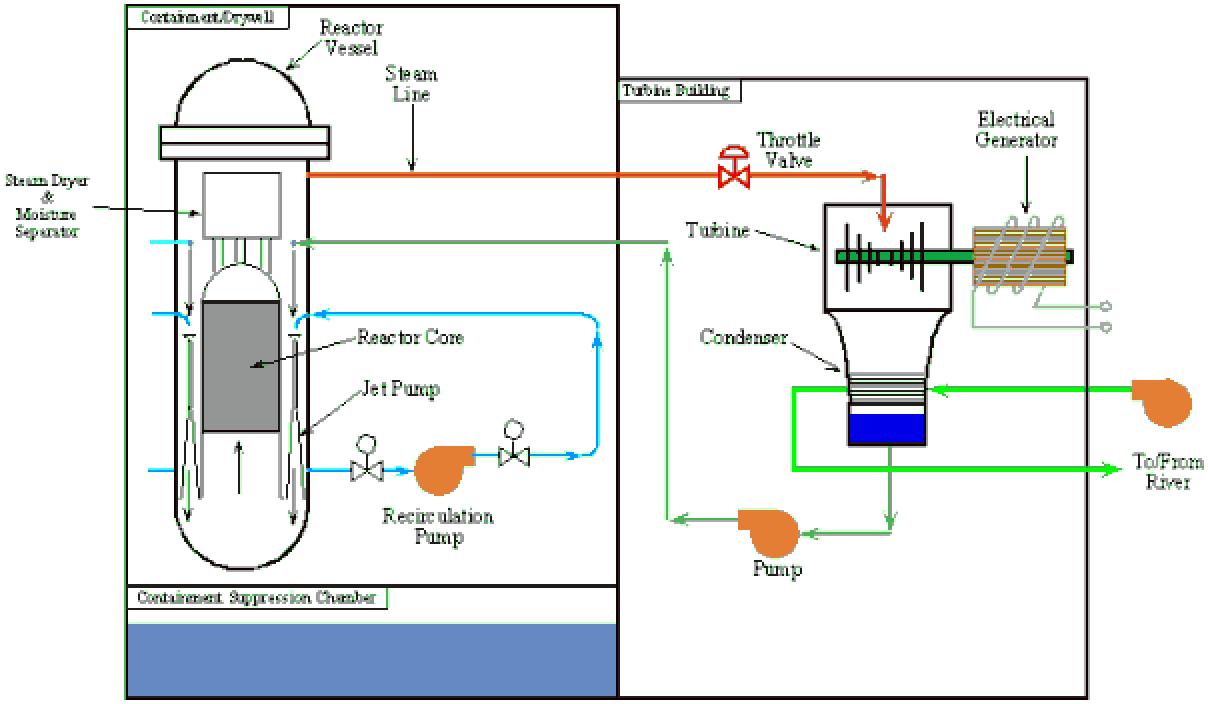
> Some plants in the arid southwest use municipal effluents as a cooling water source, which must be treated first.

The remainder of this chapter provides background information on various NPP reactor designs.

2.1 Boiling Water Reactors

–In a typical BWR [pictured below], the reactor core creates heat and a single loop delivers steam to the turbine and returns water to the reactor core to cool it. The cooling water circulates by natural circulation or, in older plant designs, is force-circulated by electrically powered pumps. Emergency cooling water is supplied by other pumps, which can be powered by onsite diesel generators. Other safety systems, such as the containment building air coolers, also need electric power" (NRC 2007).

Boiling Water Reactors: General Design



Source: NRC 2007.

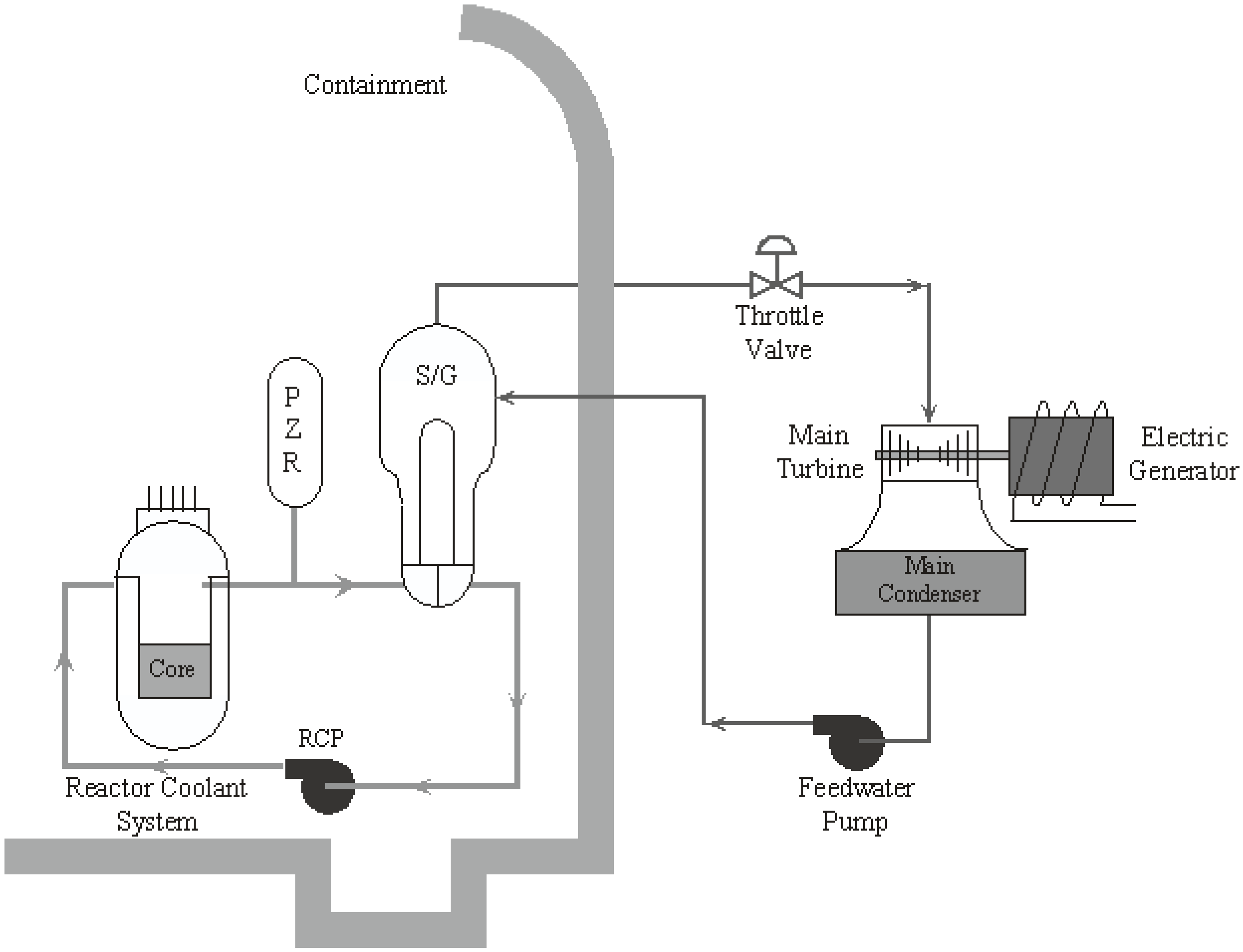
BWR designs described in detail in Appendices B through D are the Advanced Boiling Water Reactor (ABWR), Economic and Simplified Boiling Water Reactor (ESBWR), and Siedewasser Reactor-1000 (SWR-1000).

2.2 Pressurized Water Reactors

~~"~~In a typical commercial [PWR (pictured below)], the reactor core creates heat, pressurized water in the primary coolant loop carries the heat to the steam generator, and the steam generator vaporizes only the water in a secondary loop to drive the turbine, which produces electricity" (NRC 2007).

PWR designs described in detail in Appendices B through D are the advanced passive AP600 and AP1000 designs, European Power Reactor (EPR), International Reactor Innovative and Secure (IRIS), System 80+, US-Advanced Pressurized Water Reactor (APWR), and Advanced Canada Deuterium Uranium (CANDU) Reactors ACR-700 and ACR-1000.

Pressurized Water Reactors: General Design



Source: NRC 2007.

2.3 Other Reactor Designs

Reactor designs have been developed that use systems other than water to cool the reactor core and transmit heat energy to an electric turbine: the Pebble Bed Modular Reactor (PBMR) and the Gas Turbine – Modular Helium Reactor (GT-MHR) use helium as coolant; and the Toshiba Super Safe, Small and Simple (4S) uses a three-loop configuration with a primary system (sodium-cooled), an intermediate sodium loop between the radioactive primary system and the steam generators, and a water loop to generate steam for the turbine.

Each of these designs is described further in Appendices B through D.

2.4 Overview of Generation IV Concepts

Based on eight far-ranging technology goals, Generation IV nuclear energy systems are aimed at achieving nuclear energy's potential worldwide. The objective is a new generation of nuclear energy systems that “advance nuclear safety, address nuclear nonproliferation and physical protection issues, are competitively priced, and minimize waste and optimize natural resource utilization” (DOE 2008a).

Five of the six technology concepts identified in the Generation IV International Forum's Technology Roadmap are being pursued at varying levels of effort in the U.S., based on their technology status and potential to meet program and national goals.

Two are thermal neutron spectrum systems with coolants and temperatures that enable hydrogen or electricity production with high efficiency:

- very-high-temperature reactor (VHTR)
- supercritical-water-cooled reactor (SCWR)

Three are fast neutron spectrum systems that will enable more effective management of actinides through recycling of most components in the discharged fuel:

- gas-cooled fast reactor (GFR), which parallels the PBMR and original GT-MHR designs but would instead be a "fast" or breeder reactor (DOE undated).
- lead-cooled fast reactor (LFR)
- sodium-cooled fast reactor (SFR), elements of which are incorporated into the 4S design described above.

The U.S. is not currently researching the molten salt reactor (MSR) (DOE 2008b).

Section 2 References

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DOE undated: U.S. Department of Energy, Energy Information Administration. New Reactor Designs. http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss_2.html

DOE 2008a: U.S. Department of Energy, Office of Nuclear Energy. Gen IV Nuclear Energy Systems. Generation IV International Forum. http://www.ne.doe.gov/genIV/neGenIV2.html

DOE 2008b: U.S. Department of Energy, Office of Nuclear Energy. Gen IV Nuclear Energy Systems. U.S. Generation IV Priorities. http://www.ne.doe.gov/genIV/neGenIV4.html

NRC 2007: U.S. Nuclear Regulatory Commission. Power Reactors. February 12, 2007. http://www.nrc.gov/reactors/power.html

3. Environmental Description (Affected Environment)

3. Environmental Description (Affected Environment)

- Is the existing environment described in sufficient detail to form a basis for evaluating the potential for direct, indirect, and cumulative impacts?
- For resource elements where there are significant impacts, does the environmental description section provide the needed background for adequately assessing the impact for that resource?
- Does the discussion emphasize the resources that are most likely to be affected, such as water and socioeconomics?
- Is the environment described on an appropriate scale: site, vicinity, region, and, for cumulative impact analysis, transmission corridors?
- Does the EIS use quality data from reliable sources?
- Are historic changes and trends affecting a resource or feature described?
- For a COL application evaluated in a Supplemental EIS to an existing Final EIS for an ESP, does the discussion rely appropriately on the existing analysis and only supplement this information as required?
- If the NPP will be co-located at an existing power plant site, does the analysis update, as needed, information from previous NEPA analyses that are incorporated by reference or to which the new EIS tiers?

Meteorology and Air Quality

- Does the EIS contain adequate information on climate (wind, atmospheric stability, temperature, atmospheric moisture, severe weather, meteorological monitoring)?
- Does the EIS describe existing air quality, including non-attainment or maintenance areas?

Water Resources

- Does the EIS fully describe surface water hydrology?
- Does the EIS fully describe surface water use?
- Does the EIS fully describe surface water quality?
- Does the EIS fully describe ground water hydrology?
- Does the EIS fully describe ground water use?
- Does the EIS fully describe ground water quality?
- Does the EIS address water rights issues (particularly in the western U.S.)?

Ecological Resources

- Does the EIS describe terrestrial features of the site, vicinity, region, and (for cumulative impacts) transmission corridors?
- Does the EIS describe aquatic features of the site, vicinity, region, and (for cumulative impacts) transmission corridors?
- Does the EIS describe endangered, threatened, or other sensitive species and any special habitats?

Cultural and Historic Resources

- Does the EIS identify any cultural, historic, or traditional resources in the site, vicinity, region, and (for cumulative impacts) transmission corridors?
- Does the EIS describe the results of any cultural resources surveys?
- Does the EIS identify whether there are any National Register of Historic Places listed or eligible properties in the site, vicinity, region, and (for cumulative impacts) transmission corridors?

Socioeconomics

- Does the EIS include demographic data describing the population within 16 km (10 miles), the population between 16 and 80 km (10 and 50 miles), and the demographic characteristics of the 0- to 80-km (0- to 50-mile) enclosed population?
- Does the EIS identify permanent and transient populations?
- Does the EIS summarize community characteristics?
- Has information been included on potentially affected minority and low-income populations and whether they may interact with the environment in ways that create unique exposure pathways?

Geology and Seismology

- Have the geological and soil conditions been adequately described?
- Have any geologic hazards been noted?
- Have the seismic evaluation findings been summarized?

The Environmental Description section of an EIS (generally referred to as the Affected Environment section for non-NRC EISs) should provide a general description of the area that may be affected by a new NPP, with emphasis on the aspects that are most likely to be impacted, such as water resources and socioeconomics. This section assists the decision maker in determining whether resources are described in sufficient detail to form a basis for evaluating the potential for direct, indirect, and cumulative impacts of a proposed nuclear power plant. This section briefly explains why specific information is required, and reviewers should refer to the Sections 5, 6, 7, 8, and 9 of this guidance for additional context on how the information on the affected environment is used to assess potential impacts.

This section is based, in part, on review and findings from Regulatory Guide 4.2, “Preparation of Environmental Reports for Nuclear Power Stations” (NRC 1976), NRC‘s “Standard Review Plan for the Environmental Reviews for Nuclear Power Plants,” NUREG 1555 and its latest revisions (NRC 2000, NRC 2007a), and information from recent environmental impact statements for ESPs.

3.1 Requirements for the Environmental Description Section of an EIS

NRC‘s regulations at 10 CFR Part 51, Appendix A to Subpart A, “Format for Presentation of Material in Environmental Impact Statements,” specify that the EIS will describe the affected environment, as follows:

> The environmental impact statement will succinctly describe the environment to be affected by the proposed action. Data and analyses in the statement will be commensurate with the importance of the impact, with less important material summarized, consolidated, or simply referenced. Effort and attention will be concentrated on important issues; useless bulk will be eliminated [10 CFR 51, Appendix A to Subpart A].

3.2 Considerations when Reviewing the Environmental Description Section

1. **The EIS should emphasize important resources:** Emphasis should be placed on environmental parameters that would be significantly affected by any of the alternatives and only brief treatment should be given to characteristics that would be affected to only a minimal degree. The EIS should also state that, for resources predicted not to be impacted, no further analysis or discussion is warranted due to the lack of impact. NRC‘s NUREG 1555 (NRC 2000, Section 2.1) notes that the type of data and information needed will be affected by site- and station-specific factors, and the degree of detail should be modified according to the anticipated magnitude of the potential impacts.

2. **The EIS should describe the affected environment on appropriate scale:** The extent of the “affected environment” may not be the same for all potentially affected resource areas.

   As appropriate to the topic, there are four scales at which the potentially affected environment may need to be characterized (and on which impacts may need to be evaluated for all resources). These are defined as follows in NUREG 1555 (NRC 2000, Section 2.2.1, footnote a):

   - Site, defined as that area of land owned by or controlled by the applicant for purposes of constructing and operating a nuclear power plant (typically within the “site boundary”).

> Socioeconomic factors (such as demographics) should be described for a broad area extending beyond the perimeter of the site and should be described for the site, vicinity, region, and, to support the cumulative impacts analysis, along transmission corridors. In contrast, ecological resources should be described for the site and vicinity and, for assessing cumulative impacts, along transmission corridors, but they may not need to be described on a regional level (although they may need to be for certain species such as predators with a wide individual range).

- Vicinity, defined for small sites as the area within a radius of 10 kilometers (km) (6 miles); for irregularly shaped sites, the vicinity is a band or belt 10 km (6 mi) wide surrounding the plant site (it will include any pond or reservoir required for plant operation). The intent is to investigate land use in an area in which the site makes up no more than 10% of the area.

- Region, defined as an area within an 80 km (50 mile) radius of the station site, but excluding the site and vicinity.

- Transmission corridors (a preconstruction activity evaluated for cumulative impacts only) and offsite areas (for example, construction of cooling water intake and discharge pipes extending beyond the site perimeter; pumps and pipes to bring coastal water to plants that may be several miles inland; and rail spurs or barge docks constructed for import of large components and construction modules).

3. **The EIS should use quality data from reliable sources:** Both quantitative and qualitative information should be provided. Reliable and accurate information should be obtained using acceptable practices or reliable sources for each resource area.

4. **Temporal changes to the affected environment should be described:** If available, historic changes and trends affecting a resource or feature, up to and including present conditions, should be described to set the stage for the projection of future changes and trends concerning that resource or feature.

5. **License type will influence the level of detail provided in an EIS*:*** The level of detail on the affected environment for a proposed plant that has already received an ESP will rely heavily on the earlier NRC NEPA review (ESP EIS), and will only supplement this information as required, to eliminate unnecessary redundancy where conditions have not changed or no new information has been identified.

6. **For new plants proposed for construction at sites of existing operating plants, significant information on the affected environment may be referenced from existing NEPA evaluations:** Of the 20 new nuclear power plant applications expected by NRC between 2007 and 2010, for which the site is known, 14 are proposed to be located at the site of an existing operating plant (NRC 2008). License renewal EISs may also be referenced or may have useful information that is incorporated by reference. The reviewer should be sure information is updated where required.

3.3 Key Affected Resource Issues for New NPPs

The reviewer is referred to NRC‘s ―Standard Review Plan for the Environmental Reviews for Nuclear Power Plants," NUREG 1555 (NRC 2000, Section 2; NRC 2007a, Section 2), for detailed data and information needs that NRC requires for each resource area. The resource areas presented in Section 2.0 ―Environmental

> Major areas of potential impact or public concern that would likely be emphasized in the environmental description discussions (in support of impact analyses) could include water resources, land uses, ecological resources, and socioeconomic / environmental justice factors.

Description” (the affected environment section) of the standard review plan include land use, historic and cultural resources, meteorology and air quality, geology, hydrology, ecology, socioeconomics and environmental justice, the radiological environment, and related federal projects. In the case of geology, the discussion in the EIS may be very limited since “the potential for geological impacts is small and will be evaluated as part of the safety evaluation” (NRC 2000, Section 2.6).

Resources should be described in sufficient detail to form a basis for evaluating the potential for direct, indirect, and cumulative impacts of the proposed NPP. Because of the vast potential differences between sites and plant designs, a simplified checklist of information needs for each resource area cannot be provided in this guidance. The reviewer should assess the conclusions regarding impacts to each resource area to verify that adequate information was provided in the environmental description section to substantiate the conclusions. General information requirements for some resource areas that are typically important in an NPP EIS are described below.

3.3.1 Meteorology and Air Quality

Climate information, including the anticipated regional effects of climate change, is particularly relevant to cooling system operation (affected by ambient temperature) and potential health and safety/accident impacts (for example, from high winds, extreme weather events such as hurricanes or tornadoes).

Onsite meteorological data are needed to evaluate the potential environmental impacts of heat dissipation to the atmosphere and the routine and accidental releases of radiation and nonradiological effluents to the atmosphere; therefore, sufficient meteorological data is required for adequate characterization of atmospheric transport and diffusion processes within 80 km (50 miles) of the plant. At least one annual cycle from the onsite meteorological program should be used for atmospheric transport and diffusion calculations. NUREG 1555 (NRC 2000, Section 2.7) describes acceptable sources of meteorological information that should be used in addition to the onsite meteorological program. These may include National Weather Service stations, other nuclear facilities, university, and private meteorological programs, and supplementary meteorological facilities established by the applicant (or others) to characterize relevant conditions at critical onsite and offsite locations.

The EIS should also include a description of regional air quality, including non-attainment or maintenance areas. If the NPP is proposed for location in or near non-attainment or maintenance area, a conformity analysis for criteria pollutants may be required in accordance with 40 CFR 51.850 – 51.860; the details of the conformity analysis will usually be provided in the construction and/or operations impacts chapters of the EIS.

3.3.2 Water Resources

The EIS should include a full description of surface and groundwater hydrology, water use, and water quality. Information on consumptive water uses that could affect water quality and supply or that could be adversely affected by the proposed action includes the cooling water source, locations of diversions and returns, amount used and seasonal use patterns, and water rights.

Water rights will be of particular concern in the western U.S. where water is scarcer. Recreational, navigational, and other non-consumptive water uses, including those that could be affected by offsite area construction and operation should be described, considering location, activity, amount used, and seasonal use patterns. Water uses that provide potential pathways for both radiological and non-radiological effluents, including water sources, locations of diversions for consumptive uses, locations of receptors for non-consumptive uses, amount used, and seasonal use patterns are also necessary for impact analysis.

The EIS should clearly describe the existence of any designated (under §1424(e) of the Safe Drinking Water Act) sole source aquifer, within the proposed facility boundaries or in the region, to support analysis of this issue in the construction and operations impact chapters of the EIS.

3.3.3 Ecological Resources

The EIS should describe ecological (terrestrial and aquatic) features of the site and vicinity, transmission corridors (for evaluating cumulative impacts), transportation corridors (to evaluate effects of increased commuting and heavy vehicle traffic during construction), and region, with emphasis on plant and animal communities that may be affected by the proposed action. The EIS should include a description of ecological resources (including endangered, threatened, and rare/important species with estimates of their abundance) and special habitat needs of species in the area. Designated critical habitat should be identified.

3.3.4 Cultural and Historic Resources

The EIS should describe any known cultural and historic resources at the site and in the vicinity, along transmission corridors (for evaluating cumulative impacts from this pre-construction activity), and in the region. The EIS should also describe any traditional cultural resources. Cultural resources surveys of the area should be described and their results summarized. Any properties listed in or eligible for listing in the National Register of Historic Places should also be identified.

3.3.5 Socioeconomics

In the EIS, detailed information on demographic characteristics is required to assess potential social or economic impacts from plant construction or operation. Demographic data are also necessary to assess the impact of both routine and accidental releases to the environment. Specific data are required to describe the population within 16 km (10 miles), the population between 16 and 80 km (10 and 50 miles), and the demographic characteristics of the 0- to 80-km (0- to 50-mile) enclosed population. These data requirements are detailed in NUREG 1555 (NRC 2000, Section 2.5.1). EIS data requirements differ from those required for the safety analysis report because of differing objectives. Census data are used in the safety analysis report to define the exclusion area, low population zone, nearest population center boundary, and population density, and to compare these with NRC safety-related requirements (NRC 2007b, Section 2.1.3).

The EIS should describe the population distribution and community characteristics within the region that are likely to be affected by the proposed action and each alternative. The EIS should include descriptions of relevant past, current, and projected population distributions. Both permanent and transient populations should be identified, as well as minority and low-income populations. Demographics (including transient and migrant labor) and community characteristics (economy, transportation, property taxes, aesthetics and recreation, housing, public services, education) should be summarized.

The EIS should explain existing demographic data, surveys that have been performed, and uncertainties that exist. Data on low-income and minority populations, especially if any of these subgroups may be disproportionately affected by the proposed action or alternatives, should be included to support the environmental justice analysis. The EIS should present information on the potentially affected minority and low-income populations and consider whether these populations may interact with the environment in ways that create unique exposure pathways. Distribution of these populations may be diffuse and not captured by census data alone and may need to be supplemented with community-specific studies.

> Minority and low-income populations should be identified for the geographic region relevant to each resource area or impact type. For example, low-income populations may uniquely rely on certain natural resources for food or natural areas for cultural, religious, or economic reasons (DOE 2004, Section 5).

3.3.6 Geology and Seismology

Much of the detailed geology/seismology information will actually be found in the safety evaluation report (SER) that summarizes the anticipated effect of the proposed facility on public health and safety. The EIS should reference the SER and provide only a brief summary of regional and site geology, including information on the regional and local structure, the site stratigraphy, characteristics of the soil, major structural and tectonic features (for example, surface faults, vibratory ground motion), any other significant geological conditions, local and regional seismicity data, and volcanism. An important aspect in comparing alternative site suitability (with the proposed action) will be a comparison of site performance with respect to seismic vibratory ground motion requirements. The primary site characteristic of interest will be the level of ground-motion acceleration over a range of spectral frequencies of concern to engineered facilities. In some cases, existing certified plant designs will suffice; but in other cases, depending on the location, additional design (safety) features may need to be incorporated to meet site-specific seismic conditions/concerns.

The following additional types of geologic hazards would be cause for concern and should be noted in the EIS if present:

- Areas of active (and dormant) volcanic activity.
- Subsidence areas caused by withdrawal of subsurface fluids such as oil or groundwater, including areas that may be affected by future withdrawals.
- Potential unstable slope areas, including areas demonstrating paleolandslide characteristics.

- Areas of potential collapse (for example, karst areas, salt, or other soluble formations).
- Mined areas, such as near-surface coal mined-out areas, as well as areas where resources are present and may be exploited in the future.
- Areas subject to seismically induced floods or water waves.

Section 3 References

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DOE 2004: U.S. Department of Energy, Environment, Safety and Health, Office of NEPA Policy and Compliance. Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, Second Edition. December 2004. http://www.gc.energy.gov/NEPA/documents/green_book2004_12_30_final.pdf

NRC 1976: U.S. Nuclear Regulatory Commission. Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations (Rev. 2). http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/

NRC 2000: U.S. Nuclear Regulatory Commission. NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2007a: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555, draft revisions. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html

NRC 2007b: U.S. Nuclear Regulatory Commission. NUREG 0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/ch2/

NRC 2008: U.S. Nuclear Regulatory Commission. Expected New Nuclear Power Plant Applications. Updated April 23, 2008. http://www.nrc.gov/reactors/new-licensing/new-licensing-files/expected-new-rx-applications.pdf

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4. Site Layout and Plant Parameter Envelope

4. Site Layout and PPE

- If the EIS is for a COL or an operating license, it must specify the reactor design.
- Does this chapter present the overall appearance of the facility and the layout (with a map) of onsite and offsite plant structures?
- Are there any plans for secluding and screening the facilities visually, or for aesthetic design concepts?
- Does the EIS provide adequate detail to support the impact assessment regarding:
  - Reactor power conversion system
  - Plant water use
  - Water consumption
  - Water treatment
  - Cooling system
  - Radioactive waste management system
  - Nonradioactive waste systems
  - Power transmission systems
  - Power transmission system
  - Transportation of radioactive materials
- Are all the quantitative and qualitative descriptions set forth in the Plant Description chapter consistent with the assumptions presented in the environmental impact analysis chapters?

Typically, Chapter 3 of an EIS for new NPP presents the plant description, which addresses the key site structures, systems, and plant parameters that characterize the proposed NPP.

An ESP application does not need to specify a reactor design; however, NRC‘s EIS for the ESP must evaluate the potential impacts of issuing a permit for a reactor at the proposed location. Therefore, an ESP EIS may describe the plant parameter envelope (PPE), a –bounding” description. An ESP application may present a PPE as a surrogate for a nuclear power plant and its associated facilities, in contrast to the specific reactor design that is assessed in a COL EIS. This concept and related issues are described further in Section 4.2.

> Representative ground-level photographs taken from different vantage points and architectural renderings can be particularly effective in conveying this information. Such photographs and drawings will have been developed as part of the applicant‘s environmental report, and therefore should be available for inclusion in this chapter of the EIS.

4.1 Site Layout and Plant Description

The site layout discussion should present the overall appearance of the facility and the layout of onsite and offsite plant structures (for example, cooling towers, cooling tower plume, buildings, access roads, and intake and discharge structures) and a map of the proposed structures. The site layout clarifies the physical scope of the proposed project and is used to assess visual impacts, various land use impacts, and socioeconomic impacts of the plant (NRC 2000, Section 3.1). This section should also present any plans for secluding and screening the facilities, architectural approaches to visually integrate the facility into its surroundings, and any particular aesthetic concepts applied to site layout.

EPA reviewers should also expect to see a detailed plant description, as NRC requires in NUREG 1555 (NRC 2000, Section 3.0). The station [4] effluents and station-related systems that interact with the environment should be described in particular detail. The plant description should address the following systems in enough detail to support the assessment of potential environmental impacts:

- Reactor power conversion system
- Plant water use
- Water consumption
- Water treatment
- Cooling system
- Radioactive waste management system
- Nonradioactive waste systems
- Power transmission systems
- Power transmission system
- Transportation of radioactive materials

A thorough technical review of the Draft EIS should demonstrate that all the quantitative and qualitative descriptions set forth in the Plant Description chapter are consistent with the assumptions presented in the environmental impact analysis chapters. Any inconsistencies (including potential inconsistencies due to lack of clarity or precision in the Plant Description) should be noted in reviewer comments.

In recent ESP EISs, the Plant Description details are presented in the context of the PPE, where bounding assumptions are identified that allow the analysis of impacts to proceed. At the COL stage of an NPP for which an ESP EIS depended on the PPE approach, the plant description should include sufficient detail on the plant design to demonstrate that it falls within the parameters specified in the ESP EIS (NRC 2000, Appendix A-5).

4.2 PPE Concept and Issues

> The PPE concept can be used to provide an upper bound on the number and thermal power levels of proposed units, maximum levels of liquid and gaseous radiological effluents, thermal effluents, solid radioactive waste effluents, types of cooling systems, and intakes and outflows.

Because ESPs are good for 10 to 20 years and can be renewed for an additional 10 to 20 years (NRC 2004), the reactor design may not be known at the time of application. But, to satisfy NEPA requirements, information on the potential environmental impact of the unspecified future plant must be provided with the ESP application. Therefore, the PPE concept was developed to provide required plant information. The

[4] The terms ―statin" and ―plant" are often used interchangeably by applicants. NRC defines the station as all the existing and proposed buildings and structures on the applicant's property connected with electricity production, including any connected offsite water intakes or discharges but excluding any offsite transmission lines and facilities. NRC defines the plant similarly, but excludes units already in operation.

PPE provides bounds for assessing the environmental impact and determining site suitability. Instead of identifying a particular reactor design, applicants use parameters of surrogate reactors, which represent the range of possibilities for the final design. “If future technologies have fundamentally different critical parameters than those encompassed by the PPE, or unbounded parameters, those safety and environmental issues would potentially require NRC review during the COL application” (NRC 2002).

The PPE does not apply to COL applicants because, at the COL stage, a reactor design must be specified either by referencing the design control document of a certified design, or providing an equivalent level of information on an uncertified design. Therefore, the PPE concept will only potentially appear in EISs for ESPs. If a PPE-based analysis is conducted in an ESP EIS, and the environmental impacts it predicts are found to be bounding at the COL stage, no additional analysis of these impacts is required for the Supplemental EIS for the COL (NRC 2004, Attachment 3). Any environmental impacts not considered or not bounded at the ESP stage should be assessed at the COL stage. In addition, measures and controls to limit adverse impacts should be identified and evaluated for feasibility and adequacy in limiting adverse impacts at the ESP stage, where possible, and also at the COL stage.

The PPE approach created some confusion for the initial applicants completing ESP EISs. A lessons learned report (DOE 2008) based on NRC ESP hearings stated that:

> The use of the Plant Parameter Envelope (PPE) approach, when the applicant has not yet chosen a reactor technology, proved to be a major source of confusion between applicants and NRC. This issue had also been a topic of discussion during the NRC ESP hearings. Based upon North Anna and Grand Gulf [COL] experiences, the need should be evaluated for future NRC guidance pertaining to the PPE approach to clarify these issues [DOE 2008].

As there remains uncertainty regarding use of the PPE approach, EPA §309 reviewers may need to look at the sufficiency of information that supports conclusions on environmental impacts.

EPA comments on the Draft EIS for the ESP at the North Anna ESP site raised specific issues with the PPE approach in that environmental analysis. The document was found to be too broad in its consideration of potential plant designs. For some designs, reasonable data did not exist for assessing environmental impacts. The PPE approach was also found to be less credible when used to encompass reactor designs for which no accurate design parameters exist (gas cooled reactors and IRIS) (EPA 2006).

Section 4 References

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DOE 2008: U.S. Department of Energy. Report on Lessons Learned from the NP 2010 Early Site Permit Program, Final Report. Prepared by Energetics Incorporated, March 26, 2008. http://www.ne.doe.gov/pdfFiles/FinalReportonESPLessonsLearned.pdf

EPA 2006: U.S. Environmental Protection Agency. Comments to Supplement 1 of the DEIS for ESP at North Anna ESP Site. August 28, 2006. http://www.epa.gov/reg3esd1/nepa/comments/North%20Anna%20ESP%20DEIS.pdf

NRC 2000: U.S. Nuclear Regulatory Commission. NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2002: U.S. Nuclear Regulatory Commission. Early Site Permit Meeting with Nuclear Energy Institute, meeting handouts. ADAMS accession number 004089395.

NRC 2004: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. NRR REVIEW STANDARD, Processing Applications for Early Site Permits, May 3, 2004. ADAMS accession number 050600127.

5. Construction Impacts

5. Construction Impacts

- Are all activities that are considered “preconstruction” identified as such, and analyzed for cumulative impacts?
- Are the plant-specific construction plans clear enough so that the reader can understand whether all areas of potential impact have been appropriately identified and evaluated in the EIS?
- For a COL application evaluated in a Supplemental EIS to an existing Final EIS for an ESP, does the discussion rely appropriately on the existing analysis and only supplement this information as required?

Land Use

- Does the EIS identify any potential conflicts among federal, state, local, or tribal land use plans, including coastal zone management areas?
- In evaluating cumulative impacts, does the EIS identify the total acreage and current land uses that will be affected by construction?
- Does the EIS include an appropriately detailed assessment of the cumulative impacts from upgrades to any existing transmission system and the extent to which existing rights-of-way may be used, proposed routing and distance/length of new rights-of-way, general methods of construction, and existing land uses along corridors?

Historic Resources

- Are potential effects on historic properties considered, in terms of cumulative impacts due to preconstruction and any direct impacts from construction?
- Does the EIS summarize any surveys and consultations regarding cultural and historic resources?

Air Quality

- Does the EIS clearly explain models and assumptions used to quantify air emissions and air quality impacts?
- Does the EIS describe impacts in terms of duration, severity, their likelihood of occurring, and regulatory compliance?
- Does the EIS list the construction permits, notices, and approvals required to comply with the Clean Air Act, Prevention of Significant Deterioration regulations, and state regulations?
- If the site is in an area of non-attainment or maintenance, has a conformity analysis been conducted for construction emissions?

Water

- Does the EIS describe any hydrological alterations occurring during construction?
- Does the EIS state how water for construction activities will be obtained and evaluate impacts?

Ecological Resources

- Have construction effects on aquatic species and habitat been considered?
- Have potential effects to benthic communities (from dredging) been considered, such as the disruption of potentially contaminated bottom sediments?
- Have pre-construction impacts on terrestrial habitat (destruction, loss of vegetative cover) been identified for consideration as cumulative impacts in the analysis?
- Does the EIS consider impacts to ecosystems as a whole, in addition to impacts to key organisms?
- Does the analysis evaluate impacts to both common and protected species and both resident and transient species?
- Does the discussion explain the methods or models used to evaluate ecosystem impacts?
- Is compliance documented with the relevant requirements of the Endangered Species Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act, Bald and Golden Eagle Protection Act, and Coastal Zone Management Act?

Socioeconomics

- Have construction workforce impacts been adequately and appropriately assessed in terms of available community services and infrastructure?
- Does the evaluation of physical impacts (such as noise, odors, visual) provide context in terms of construction location relative to sensitive receptors?
- Is the assessment of public services, housing, and other local economic impacts discussed in terms of the availability of local labor vs. the need for an in-migrant construction population that would increase demands on existing public services, housing, and other local conditions?
- Does the environmental justice analysis address the following questions:
  - Are the radiological or other health effects significant or above generally accepted norms?
  - Is the risk of rate of hazard significant and appreciably in excess of the general population?
  - Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
  - Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
  - Are there any significant adverse impacts on a group that appreciably exceed or [are] likely to appreciably exceed those in the general population?
  - Do the environmental effects occur or would they occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? [NRC 2004b, Appendix D-10]

- Does the analysis of potential environmental justice issues consider the following:
  - The locations of minority and low-income population residential areas relative to the construction site.
  - Any past benefits from construction and operation of the previous / current generation of plants.
  - The skill levels required for construction and the extent to which construction employment could be supplied by minorities and low-income populations.

Radiation Exposure to Construction Workers

- Does the EIS summarize annual radiation doses to construction workers from adjacent operating unit(s), including exposures from direct radiation, gaseous effluent releases, and liquid effluent releases?
- Does the analysis include models, assumptions, and input data?

Waste

- Are construction waste impacts evaluated in the EIS?
- Is waste generated in association with preconstruction activities assessed as a cumulative impact?

In general, construction activities for a new nuclear power plant would be similar to those associated with construction of any large industrial complex. This section targets those impacts that are unique to or of greatest concern for constructing an NPP: land use, water, ecology, socioeconomics and environmental justice, radiation exposure to construction workers, and waste. This list includes five topics identified by NRC for detailed EIS analysis from construction impacts in ―Standard Review Plan for Environmental Reviews for Nuclear Power Plants," NUREG 1555 (NRC 2000, Section 4.0). In addition, air quality and waste generation are included in this discussion of construction impacts that may require attention by EPA §309 reviewers.

Sources of information for this section include review and findings from NRC's Regulatory Guide 4.2, ―Preparation of Environmental Reports for Nuclear Power Stations" (NRC 1976), NUREG 1555 (NRC 2000, Section 4.0; NRC 2007a), and information from recent environmental reports for COL applications and EISs for ESPs.

A breakout of construction activities considered to be part of pre-construction (not regulated by NRC) from those associated with full plant construction and operation (NRC-regulated activities) is important in evaluating potential cumulative impacts of these connected actions. The NRC recently amended its regulations (effective November 8, 2007) applicable to limited work authorizations (LWAs) that allow certain construction activities on production and utilization facilities, including new nuclear power reactors, to commence before a construction permit or COL is issued. The final rule modifies the scope of activities that are considered construction for which a construction permit, COL, or LWA permit is necessary; identifies activities considered as pre-construction and therefore outside of NRC's authority (see item 4 in Section 5.1 below); specifies the scope of construction activities that may be performed under an LWA; and changes the review and approval process for LWA requests (10 CFR Parts 2, 50, 51, 5 2, and 100). NRC guidance on how this will be handled has been drafted and issued for public comment. Applicants seeking an LWA currently have the option of preparing either two environmental reports (one for activities for which an LWA is sought and a second one for full plant construction and operation), or one environmental report with a clear breakout of the scope of the two types of activities so that potential cumulative impacts can be evaluated. <u>In an NRC EIS, any activities that are considered pre-construction are not within NRC's regulatory authority but must be clearly identified, and are evaluated only in terms of their cumulative impacts along with the impacts of NPP construction and operation </u>(NRC 2007b).

Appendix H of this guidance, ―Useful Tools for Quick Reference," identifies other reference sources (and website links) with for EPA §309 reviewers requiring more details on specific aspects of the impacts of NPP construction.

5.1 Review Considerations

Site conditions, the proposed design, and even the license type affect the scope and level of analysis included in an EIS. To help put the construction of next generation NPPs into context for EPA's §309 EIS reviewers, the following review guidelines are noteworthy:

1. **New construction methods will rely in part on modular construction performed in other parts of the country, with components transported to the site via truck, rail, or barge, depending on their size.** The extensive use of prefabricated modules is planned to expedite the construction of new reactor units, by centralizing fabrication to facilities where a qualified workforce with the necessary experience and skills can perform the specialized construction activities. As many as 600 prefabricated modules have been estimated to be possible for a NPP (Dominion Energy et. al 2004). The maximum size of a module or sub-module fabricated off-site would be 12 feet by 12 feet by 80 feet to allow shipment by rail or truck. Larger structural and equipment modules would be field-assembled from multiple sub-modules. These include mechanical equipment modules, piping/electrical/valve modules, structural modules, electrical equipment modules, reinforcing steel modules, and piping assemblies (DOE 2005). The offsite/out-of-country impacts of module construction would not be addressed in detail in the EIS since they are considered to be preconstruction. Modular construction would help reduce onsite construction impacts compared to the previous generation of NPPs.

2. **Plant size, design, and location must be understood and considered:** The degree and extent of construction impacts will depend on the number of units being proposed, the design of the units (for example, some reactor designs may require different cooling water systems or more construction workers than other designs), and the plant's location. Regarding plant design, it is important for the EPA reviewer to understand the specific plant design requirements / parameters (see Section 2 and Appendices B through D) to understand whether all areas of potential impact have been appropriately identified and evaluated in the EIS. Regarding plant location, construction impacts will vary depending on whether the site is an undeveloped greenfield location, contains an existing NPP or other type of power plant (such as coal), or is at any other type of brownfield site (that is, a previously disturbed site). Impacts, in general, would be expected to be less at an established power plant site due to

existing infrastructure and previously disturbed land; however, the co-location of plants could contribute to potential cumulative impacts that the EPA reviewer may review to determine whether they have been sufficiently addressed (that is, the combined impacts of new plant construction with existing plant operations). See Section 11 for further discussion of cumulative impacts. Construction on a greenfield site will generally require the EIS to provide more attention to the potential for cumulative impacts on resources frequently associated with undisturbed sites, including land use, ecological resources, and archaeological or historic resources; these are further discussed in Sections 5.2, 5.5, and 5.2.3, respectively.

3. **License type will influence the level of analysis in the EIS:** The level of detail in a Supplemental EIS for a COL for a proposed plant that has already received an ESP will rely heavily on the earlier NRC NEPA review (ESP EIS), and will only supplement this information as required, to eliminate unnecessary redundancy where conditions have not changed or no new information has been identified.

4. **Pre-construction activities and LWAs should be considered:** NRC‘s authority (and corresponding NEPA review) only extends to ―activities that have a reasonable nexus to radiological health and safety and/or common defense and security for which regulatory oversight is necessary and/or most effective in ensuring reasonable assurance of adequate protection to public health and safety" (NRC 2007b). NRC regulations acknowledge that certain pre-construction activities for NPPs could commence before a CP or COL is issued, and that these are outside of NRC‘s regulatory authority. NRC defines the following activities as explicitly not part of construction, and therefore not within their authority (NRC 2007b):

> (i) Changes for temporary use of the land for public recreational purposes;
> (ii) Site exploration, including necessary borings to determine foundation conditions or other preconstruction monitoring to establish background information related to the suitability of the site, the environmental impacts of construction or operation, or the protection of environmental values;
> (iii) Preparation of a site for construction of a facility, including clearing of the site, grading, installation of drainage, erosion and other environmental mitigation measures, and construction of temporary roads and borrow areas;
> (iv) Erection of fences and other access control measures;
> (v) Excavation;
> (vi) Erection of support buildings (such as, construction equipment storage sheds, warehouse and shop facilities, utilities, concrete mixing plants, docking and unloading facilities, and office buildings) for use in connection with the construction of the facility;
> (vii) Building of service facilities, such as paved roads, parking lots, railroad spurs, exterior utility and lighting systems, potable water systems, sanitary sewerage treatment facilities, and transmission lines;
> (viii) Procurement or fabrication of components or portions of the proposed facility occurring at other than the final, in-place location at the facility;
> (ix) Manufacture of a nuclear power reactor under a manufacturing license under subpart F of part 52 of this chapter to be installed at the proposed site and to be part of the proposed facility; or

(x) With respect to production or utilization facilities, other than testing facilities and nuclear power plants, required to be licensed under Section 104.a or Section 104.c of the Act, the erection of buildings which will be used for activities other than operation of a facility and which may also be used to house a facility (e.g., the construction of a college laboratory building with space for installation of a training reactor.

Therefore, some pre-construction activities outside of NRC's authority may be excluded from the analysis in the EIS, but EPA reviewers should ensure that the cumulative effects analysis for the construction that is proposed in the EIS also considers the impacts of any such pre-construction activities that were outside of NRC's purview.

Within the scope of their authority, NRC may issue an LWA allowing an applicant to perform the driving of piles; subsurface preparation; placement of backfill, concrete, or permanent retaining walls within an excavation; or installation of the foundation, including placement of concrete; any of which are for a structure, system, or component of the facility for which either a CP or COL is otherwise required. An applicant may apply for an LWA as part of an application for a CP or COL. For such activities that are within NRC's authority, EPA reviewers should be able to identify that NRC has included these activities within the construction activities for which direct, indirect, and cumulative impacts are analyzed.

5. **Lengthy construction periods:** While many construction impacts may be temporary, the construction period for a NPP is lengthy and may result in substantive impacts during peak activity years on some resources and at some sites, possibly requiring mitigation beyond best management practices. This could be further exacerbated if construction of more than one unit is planned at an existing site, in terms of impacts to existing commuting workforce (construction and operations) and impacts to existing plant operations/activities. Some vendors estimate that over five years will be required from contract to commercial operation (Dominion Energy et al. 2004).

6. **Offsite construction:** NEPA requires that both onsite and offsite impacts be addressed in an EIS, and NRC NEPA guidance is consistent with this requirement. However, EPA reviewers should be aware of the terminology that may be used by NRC, consistent with its guidance in NUREG 1555 (NRC 2000, Section 2.2.1, footnote a) and which includes a further breakout for offsite impact areas. As appropriate to the topic, NRC identifies four scales on which impacts may need to be evaluated; these were listed and described in Section 3.2, Item 2 of this guidance document.

7. **Cumulative impacts related to transmission lines:** The cumulative impacts of transmission lines, which are outside of NRC's authority to regulate, must be considered. Construction impacts for transmission lines for NPPs are not different than for non-nuclear power facilities. Some considerations for EPA review are (1) whether or not proposed transmission lines are on existing right-of-way or if a new right-of-way is required; (2) the total miles of new lines and width of the right-of-way; and (3) if the proposal is to co-locate an NPP with an existing plant, identification of required upgrades to the existing transmission lines.

8. **NRC's terminology regarding the characterization of impacts:** The three EISs for ESPs completed to date follow the practice used by NRC in the "Generic Environmental Impact Statement for License Renewal of Nuclear Plants," NUREG-1437 (NRC 1996) and supplemental operating license renewal EISs. This practice is expected to be used for new EISs. In this approach, the size and severity of environmental impacts are described using the terms "small," "moderate," or "large." These terms are defined in NRC's regulations (10 CFR 51, Appendix B, footnote 3) as follows

   - Small - Environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource
   - Moderate - Environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
   - Large - Environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource [10 CFR 51, Appendix B, footnote 3]

The potential construction impacts described in the remainder of this section are intended to provide EPA reviewers with resource-specific information for evaluating NRC‘s analysis and conclusions regarding impacts.

5.2 Land Use

Although evaluation of impacts from NPP construction on land use are limited to cumulative impacts, it is recognized that a significant and frequently controversial consideration related to siting a new NPP is the compatibility of the NPP with adjacent and nearby land uses, both existing and proposed. NRC‘s siting criteria give preference to areas of low population density (10 CFR 100.21(h)). In evaluating siting alternatives, an NPP EIS should give due consideration to ―possible conflicts between the alternatives and the objectives of federal, state, regional, . . . local [, and] tribal land use plans, policies, and controls for the area concerned," and discuss compliance with zoning and land use regulations (NRC 2007a, Section 4.1.1). Siting an NPP in a location would also be likely to affect future land use and zoning decisions, as well as affect siting decisions for a wide range of future developments, including housing, schools, hospitals, and other facilities. Potential effects on property values and housing marketability are addressed in Section 6.7.2.1 of this guidance document. Issues identified during the scoping phase, which should be summarized in the EIS, will likely provide some perspective for EPA §309 reviewers on actual and perceived (which ultimately may be equally important) conflicts with local land uses.

Locating a new NPP at a site would include clearing, dredging, grading, excavation, spoil deposition, and dewatering activities. Many of these activities are considered pre-construction (outside of NRC‘s authority), and would therefore only be evaluated in the EIS in terms of cumulative impacts (and not for alternative approaches to them or specifying mitigation). The total impacted area onsite could include up to several hundred acres (or more if a new reservoir is constructed), although the majority of acreage should be affected only temporarily and be able to be restored following plant construction. Construction would be largely focused in one central location and typically include plant structures, parking lots, switchyards, intake and discharge lines, cooling ponds, a construction lay-down area, and a possible rail spur (which can also extend offsite). If a reservoir is needed, the area to be disturbed would be further increased. The area permanently disturbed varies with the design and number of units. Impacts would also occur within and near any surface water body used for cooling water makeup/blowdown. In the western U.S., where surface water resources are more limited (or not available to NPPs), cooling water sources may include (1) gray water (municipal waste water), which would require the construction of lines from the municipality(ies) to the power plant; or (2) groundwater, which could require up to several hundred (or thousands) more acres of land for developing a well field from which to pump the necessary groundwater. Impacts to existing land use from these related activities should also be addressed. Following construction, areas without constructed buildings or transportation infrastructure would typically be reclaimed to the greatest extent to minimize permanent impacts. Construction of a new facility would result in some alterations of current land use.

Land requirements for an NPP can be significant, depending on the selected design, the number of units proposed, whether a cooling pond or reservoir will be required, and the length of new transmission line that is proposed. Changes in existing land use and zoning laws may present challenges and are potential concerns in terms of cumulative impacts (for example, prime farmland, protected lands, sensitive resources/critical habitat, coastal zone). Land ownership (private, public, protected lands) may also be a concern where extensive public land crossings (such as of national forests or parks or other public lands) are required to provide site access, to access cooling water, or for utility and transmission corridors.

5.2.1 Site and Vicinity

Within the cumulative impacts analysis, the EIS should identify the total acreage and current land uses that will be affected by construction. This should include both onsite impacts (such as those from the plant footprint and auxiliary facilities) and offsite impacts (for example, transmission/utility corridors), and the extent to which existing land uses (and acreages) may be able to be restored following any short-term impacts from construction, versus long-term impacts or permanent changes in land use due to plant operation. Onsite cumulative impacts from land use changes could result from direct disturbance to the land (for example, under the proposed plant footprint or for a reservoir), as well as a change in land use when an applicant purchases adjacent land (such as farmland in the site, thereby taking it out of production) to obtain the necessary buffer or control over the site perimeter.

Reviewers should check that the EIS has identified any potential conflicts among federal, state, local, or tribal land use plans. This would include coastal zone management areas, given that plants may rely on coastal waters as a potential source for cooling water supply.

5.2.2 Transmission Corridors and Offsite Areas (Cumulative Impacts Only)

Primary land use impacts from constructing transmission corridors and other utility corridors include removal of trees and vegetation (for undeveloped corridors), and the re-clearing of existing transmission line right-of-ways.

As general background, the existing transmission system throughout the U.S. is very limited. The level of impact will depend on the amount / length of new transmission line that will need to be cleared / constructed and the resulting change in land use. The presence of a transmission line and its right-of-way would preclude certain productive land uses from continuing on that land (such as forestry or agriculture).

> Development of new plants may require major upgrades to the existing transmission system and even new corridors across extensive areas to reach the population load/demand. Less potential for environmental impacts (and lower overall construction costs) would be presented for plants that are able to make use of an existing corridor to the extent possible. However, even development of new reactors at existing power plant sites may require additional transmission line rights-of-way, depending on the feasibility of using the existing infrastructure and the available capacity remaining in the system. If sufficient capacity is not available, existing rights-of-way either would have to be expanded to accommodate additional transmission lines or new rights-of-way would have to be obtained and transmission lines constructed.

Crossing any federal land by a new transmission corridor (for example, Bureau of Land Management land or National Forest, particularly in the western U.S.) would likely require a separate NEPA review by the federal landowner to address site-specific impacts to the public land. This related NEPA documentation should be identified in the NPP EIS, as appropriate.

Other offsite areas that could be affected include additional corridors required to construct the cooling water intake and/or plant discharge lines, depending on how far the plant is located from the cooling water supply source, or transportation access (new rail spur or barge terminal) to deliver large / heavy plant components to the site. Acreage requirements and changes in land use for these areas should also be addressed.

5.2.3 Historic Properties (Generally Cumulative Impacts Only)

Impacts to historic properties from NPP construction should be no different than impacts from a typical large construction project. Land clearing and excavation activities associated with pre-construction could adversely affect known and unknown (not yet identified) archaeological, cultural, or historic resources of an area. Some parts of the country are very rich in historic resources and the risk for cumulative impacts is high, particularly if a site is located in an undeveloped area. In addition to direct disturbance, dust and noise from construction could impact visitors to historic or cultural resources in the vicinity of the property.

To comply with federal historic preservation laws and regulations as well as the mandates of NEPA, historic properties must be identified in an area potentially affected by a project undertaken or licensed by a federal agency, including independent agencies such as the NRC, and potential effects on these properties must be considered. The principal driver for the process is Section 106 of the National Historic Preservation Act (NHPA) and implementing regulations at 36 CFR Part 800, as amended (August 2004). Section 106 requires consultation, prior to construction, with historic preservation entities and federally recognized Indian Tribes to ensure no historic properties are adversely affected.

The new LWA rule and the draft guidance do not address whether NRC still has a role that requires consultation under the NHPA, although the draft guidance states that ―in the impact areas of terrestrial ecology and historical and cultural resources, nearly all the impact will be from preconstruction activities" (NRC 2008a). If consultation was undertaken, the EIS should include results of consultation with the State Historic Preservation Officer (SHPO) and affected Indian Tribes. Specifically, it should summarize the results of any cultural / archaeological resource surveys and historic architectural surveys (historic structures) that the SHPO may have required to determine if potentially significant resources are present. If historic resources or properties are identified, the EIS should indicate their historic significance (that is, whether a property is eligible for listing on the National Register of Historic Places). Finally, if historic properties are identified that could potentially be affected, the potential impacts should be assessed, and mitigation included where appropriate; mitigation should be developed in consultation with the SHPO and tribes.

5.3 Air Quality Impacts

Construction activities for a new NPP would be similar to those associated with construction of any large industrial complex, with the exception of the large concrete requirements for an NPP, which may be associated with considerable on-site batch plant operations. Typical of most construction, there will be ground-clearing, grading, excavation, and movement of materials and machinery. As mentioned above, the duration of construction (over five years from contract to commercial operation) for a new NPP can be substantial and can alter air quality for this duration. The EIS should clearly explain models and assumptions used to quantify air emissions and air quality impacts, and should identify methods used in comparing baseline emissions and air quality to conditions that may result from the proposed construction activities and alternatives. The EIS should describe impacts in terms of duration, severity, and likelihood of occurring and should address regulatory compliance.

> The primary pollutant of concern for construction is particulates. Ground-clearing, grading, excavation activities (some of which may be considered preconstruction) and the movement of materials and machinery will raise dust. Fugitive dust may also rise from cleared areas during windy periods. In addition to dust from preconstruction and construction activities, smoke and other pollutants from open burning, emissions from equipment and machinery used in construction, concrete batch plant operations, and emissions from vehicles used to transport workers and materials to and from the site would impact air quality.

Exhaust from the vehicles required to transport construction equipment, prefabricated modules, and the construction workforce could decrease air quality. Though the projected workforce for a new NPP will vary, it can be assumed to be significant. On average, for construction of a new reactor unit, the total peak labor on-site is estimated at 2,400 personnel (DOE 2005, Section 3.3), though recent EISs include higher estimates: up to 5,000 for the North Anna plant for two units (NRC 2006a, Section 4.5.3). This is of greater concern if the trips are made in an area where air quality does not meet the National Ambient Air Quality Standards.

The EIS should discuss the construction permits, notices, and approvals required to comply with the Clean Air Act, Prevention of Significant Deterioration regulations, and state regulations; see a comprehensive list of potential regulatory requirements in Appendix A. If the plant is proposed for a nonattainment or maintenance area, a conformity analysis for construction emissions should be conducted and summarized. Preconstruction impacts should be included in the cumulative impacts analysis.

5.4 Water-Related Impacts

One of the primary impact areas from NPP development, relevant to both construction and operation activities, is water – specifically water supply and use, water quality, and hydrology. Related impacts to aquatic ecology are included in Section 5.5, ―Ecological Impacts.”

Several of the required government approvals or permits listed in Appendix A apply to construction activities that can affect water resources. Prior to receiving a CP or COL, applicants are required to obtain permits, certificates, and determinations regulating water use and water quality. These permits, certificates, and determinations may include a Clean Water Act §404 permit, Clean Water Act §401 certification, a Clean Water Act §402(p) National Pollutant Discharge Elimination System (NPDES) storm water permit, and special determinations regarding EPA-designated sole source aquifers. They may also include U.S. Army Corps of Engineers (USACE) permits for construction in a floodplain, dredge and fill activities, and impacts to navigable waters of the U.S., as appropriate.

5.4.1 Hydrologic Alterations

An EIS should describe the hydrological alterations occurring during construction of a new NPP and should evaluate the potential impacts to the environment that may result. There are numerous construction activities that can alter local hydrology at the site and at offsite areas. Hydrological alterations may affect ―navigation, fish and wildlife resources, water quality . . . [and] supply, [and] aesthetics” (NRC 1976, Section 4.1).

Depending upon the design and location of the proposed facility, construction of the foundation of the reactor and various other buildings may require dewatering systems to be installed. Dewatering systems would depress the water table in the local vicinity and possibly change the direction of groundwater flow and the available capacity of local wells. When construction involves dewatering for deeply excavated building foundations and cooling water canals at sites close to the ocean, dewatering can adversely affect groundwater quality by inducing saltwater intrusion (NRC 1996, Section 3.4.2).

Installing cooling systems can cause hydrological alterations that vary with design, but EPA reviewers must evaluate these impacts carefully within the context of the specific site and the design. Creating a cooling lake or pond can affect the local ecology (see Section 5.5). Other construction activities that can alter hydrology include constructing cofferdams and storm sewers; dredging operations; placing fill material into the water; creating shoreside facilities involving bulkheads, piers, jetties, basins, or other structures or activities with potential to alter existing shoreline processes; constructing intake and outfall structures; water channel modifications; constructing roads and bridges; operations affecting water levels (flooding); and construction activities contributing to sediment runoff, such as road construction, clearing and grading, and fill or spoil placement (NRC 2000, Section 4.2.1). Similar to most construction activities, NPP construction will increase impervious surface area, which could increase runoff intensity (NRC 2006a, Section 2.6.2.1). Excavation, fill, and grading operations could alter streams and wetlands (NRC 2006a, Section 4.3.1).

5.4.2 Water Use Impacts

Water use requirements for construction activities are similar to other large industrial construction projects. Water for standard construction activities, such as dust abatement, and concrete batch plant operations, would be required. Potable water supplies for the construction workforce would also be required.

The EIS should state how water for construction activities will be obtained. If additional wells are installed, the impacts to ground water should be described. Dewatering systems (see Section 5.4.1) that are active during excavation and construction could result in a decline in the local water table and affect the availability of water from onsite wells. Depending on the use for which the water is withdrawn (preconstruction or construction), these impacts may be addressed only in terms of cumulative effects. If a groundwater source is a designated sole source aquifer, the EIS should evaluate whether the proposed use would lower the water table and, if so, whether this could induce infiltration into the aquifer of water of lesser quality (including saltwater intrusion in coastal areas); this is a specific issue that EPA is responsible for reviewing under the Safe Drinking Water Act.

5.4.3 Water Quality Impacts

Water quality impacts would primarily result from erosion, stormwater runoff, and construction-related dredging in rivers, lakes, or coastal areas (such as may be required for cooling water intake structures). Activity mitigation requirements would be stipulated through NPDES and §404 dredge and fill permits obtained for the action. Excavation or dredging in areas with contaminated sediments is also a potential concern to be addressed.

Construction also may significantly increase sediment load to nearby water bodies from erosion of exposed and poorly graded soil during construction. Excavations associated with intake and discharge pipelines and reactor block and site grading for the cooling towers and other buildings will expose soil. Sedimentation can be exacerbated by meteorological conditions, such as areas with high precipitation that can cause erosive movement of sediment into streams (NRC 2006b, Section 4.3.3).

Dredging and shoreline construction will also affect water quality through increased turbidity. Dredging operations would be regulated by the USACE to protect navigation and habitat.

In the cumulative impacts analysis, adverse surface water quality impacts from utility corridor (that is, transmission line) construction must be considered as well. Soil disturbances associated with right-of-way clearing, access road construction, preparing transmission structure foundations, and other activities can cause erosion and sedimentation, clogging small streams and threatening aquatic life. Precautions would be included in the design, construction, and maintenance of the proposed transmission line to minimize potential impacts and to avoid the addition of sediment or siltation to any impaired waters. Transmission line construction could impede runoff patterns and the natural movement of aquatic fauna (TVA 2005, Section 4.2).

Finally, note that water quality and water supply are linked. The authority to regulate water quality can be extended to regulate water supply if the domestic or environmental water needs are affected by reduced water quality. An assessment of the environmental impacts resulting from construction activities may be available from a separate permitting authority (such as USACE or the state / EPA as the NPDES permitting agency) and should be incorporated into an NPP EIS (NRC 2000, Section 4.2.2).

5.5 Ecological Impacts

This section discusses how NPP construction activities may disturb the existing terrestrial and aquatic ecology. The following points apply to review of both areas:

- The EIS should consider impacts to ecosystems as a whole, in addition to impacts to key organisms. The EPA guidance, ―Considering Ecological Processes in Environmental Impact Assessments" (EPA 1999a, Introduction), provides information to EPA offices on how to incorporate ecological considerations into the preparation and review of environmental impact assessments. This guidance explains how to use an ecosystem approach, consistent with an earlier CEQ guidance (CEQ 1993). The guidance states that EISs, when relevant, should take into account the interconnectedness of processes within ecosystems. Analyses should capture all aspects of biological diversity, especially the interactions within and among ecosystems rather than focusing on a single species or a familiar habitat.

- Ecosystem impacts can be expressed at the level of the individual organisms or at the system level. Examples of effects on individual organisms include death, reduction of health or vitality, accumulation of toxic substances, and alteration of reproductive success. Examples of ecological system effects include changes in birth or death rates; changes of toxic element concentrations throughout entire food webs; and changes in population size, habitat, or community structure (NRC 1977, Section B).

- As with all environmental impacts, ecological effects should be described in terms of duration, severity, and likelihood of occurring.

- The environmental consequences to both common and protected species and both resident and transient species, should be considered and identified.

- The EIS should explain the methods or models used to evaluate ecosystem impacts for each of the construction alternatives. Certain details of construction activities may not be known at the time an ESP EIS is completed, but sufficient analysis must be completed for comparing the proposed action and alternatives.

- The EIS should document compliance with the relevant requirements of the Endangered Species Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act, Bald and Golden Eagle Protection Act, and Coastal Zone Management Act.

- Measures to minimize impacts to both terrestrial and aquatic species can include scheduling construction activities to avoid a species‘ breeding season.

5.5.1 Terrestrial Ecosystems

Adverse impacts on terrestrial organisms or ecological systems generally result from loss or modification of habitat, release of minerals or toxic chemicals into the environment, and direct destruction of biota (NRC 1977, Section B). The following paragraphs describe some activities identified in recent ESP EISs as potentially impacting terrestrial ecology, as well as activities that may have such effects as a result of any large construction project.

5.5.1.1 Habitat Destruction

NRC‘s draft guidance for implementing the new LWA rule states that ―in the impact areas of terrestrial ecology and historical and cultural resources, nearly all the impact will be from pre-construction activities" (NRC 2008a). Pre-construction activities are excluded from any NRC NEPA review except for cumulative impact assessment under the new LWA rule. Further, NRC‘s position is that they do not consult under the Endangered Species Act for activities that they are not authorizing (that is, activities that are considered to be preconstruction). The applicant would still be required to comply with the Endangered Species Act‘s prohibition against take[5] of listed species, but this issue would be outside of the scope of the EIS analysis, unless USACE is a cooperating agency. USACE cooperation is likely in many NPP EISs, in which case USACE‘s authority would extend to activities that could require NEPA analysis for direct and indirect impacts, as well as consultation under §7 of the Endangered Species Act.

The most direct impact of construction on terrestrial ecosystems is habitat destruction (which may be limited to analysis of its cumulative impact; see previous paragraph). Pre-construction, including new transmission lines and access corridors in conjunction with the station, can result in the destruction or alteration of wildlife habitats, leading to changes in the abundance of a species or in the species composition of a community.

Numerous factors will determine the extent of habitat impacts. Both temporary and permanent habitats need to be considered, including those used for breeding and nursery, nesting and spawning, wintering, and feeding. The extent of habitat destruction depends on the footprint of the proposed site, the extent of disturbance, the extent of construction occurring on previously disturbed areas compared to pristine areas, the duration of the disturbance, and how much of the disturbance would be temporary in nature versus permanent. For temporary land disturbance, the timing of the disturbance may determine whether there are impacts on migration, breeding, or nesting of individuals. The area disturbed in relation to available undeveloped land in vicinity will affect a population‘s ability to recover. The mobility of species will determine whether individuals will be displaced or destroyed, and the adaptability of species will determine their

[5] ―Take" is defined in the Endangered Species Act as ―to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." Regulations developed to implement the Act have further defined ―harm" as ―an act which actually kills or injures wildlife. Such act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering" (50 CFR 17.3).

ability to survive in altered habitat. The recovery of habitat from disturbance can also be improved, and therefore impacts on habitat decreased, by program elements such as emphasizing the use of native species in re-seeding / re-planting and implementing control measures for invasive species.

Of particular concern are potential (cumulative) impacts to habitat areas used by protected species. Designated critical habit protected under the Endangered Species Act also needs to be specifically identified and assessed, as do wetland areas that offer important habitat to variety of species, including migratory birds.

5.5.1.2 Hydrological Alterations

Installing cooling systems can cause hydrological alterations that vary with design. Creating a cooling lake or pond can affect the local ecology, including the loss of flora and local migration of fauna from the area the lake or pond will occupy (NRC 1976, Section 4.1). Modifications to a larger area surrounding a specific water intake location resulting from construction activities and changes in existing topography can also create permanent disruptions in the biological community.

5.5.1.3 Dewatering

Riparian vegetation has important ecological functions: it stabilizes stream channels and floodplains, influences biogeochemical cycles, water temperature and quality, and the duration and magnitude of flooding. It also provides diverse cover, food, water, reproductive habitat, and migration corridors for many aquatic and terrestrial animals. Riparian ecosystems support a wide variety and high density of wildlife, especially in arid or urbanized areas. Dewatering during construction may adversely affect riparian vegetation in a number of ways, including decreases in the width of the riparian corridor, changes in species and community diversity, increased susceptibility to flooding, changes in tree canopy cover, lower tree basal area, and lower seedling densities.

> Dewatering effects are most apparent in the arid and semi-arid western U.S. In the eastern U.S., dewatering effects generally involve more subtle changes in community composition because of higher precipitation, humidity, and soil moisture and the lower water stress conditions that usually prevail.

As with water use during operation, consumptive water use during construction can adversely affect riparian vegetation and associated animal communities by reducing the amount of water in the stream that is available for plant growth, maintenance, and reproduction.

5.5.1.4 Disturbance from Construction Activity

Construction activities can also affect terrestrial ecosystems due to noise, smoke, dust, releases of chemicals, and disposition of solid wastes.

5.5.1.5 Wildlife Collisions

Vehicle collisions with wildlife, and avian collisions with utility structures, can occur during preconstruction and construction, as well as during operation.

5.5.1.6 Transmission Line Impacts (Cumulative Impacts Only)

Transmission line impacts must also be considered in terms of their cumulative impact on the terrestrial ecosystem. The construction and operation of the proposed transmission line could facilitate the spread of invasive terrestrial plants already present in the project area or result in the introduction of invasive species into the area; this would be especially true where the proposed routes travel through intact forests or woodlands. In wooded areas, the initial clearing for a transmission line would likely temporarily displace large animals, such as deer and turkey, from the site. Smaller animals could be destroyed by construction activities.

5.5.2 Aquatic Ecosystems

The EIS should describe temporary or permanent loss of habitat for endangered, threatened, or special status aquatic species or loss of habitat for recreationally important species, permanent loss of aquatic habitat, or loss of wetlands. For EISs that follow NRC guidance (NRC 2000, NRC 2007a), impacts to wetlands and floodplains may be included in several places, including land use, hydrology, terrestrial ecology, and aquatic ecology (NRC 2000, Sections 2.3.1, 2.4.1, 2.4.2). As with terrestrial ecosystems, pre-construction activities are excluded from any NRC NEPA review except for cumulative impact assessment under the new LWA rule.

> Impacts to water quality and aquatic ecology are linked in that impacts to one can affect the other. As stated previously, construction activities can result in hydrological alterations, sedimentation of water bodies from erosion of exposed soil, potential releases of contaminants from construction equipment, consumptive water use, and dewatering of wetland areas, all of which can also adversely impact aquatic ecology.

Impacts on the aquatic ecosystem from constructing a new nuclear unit would be associated primarily with any new cooling water intake and discharges structures (and widening transmission line rights-of-way). The construction activities for a new cooling water intake and discharge structures include dredging, constructing cooling towers, and pipeline construction. Construction along a river or coastal area could also result in the removal or reshaping of the shoreline. These activities would likely lead to loss of benthic and shoreline habitats well as temporary displacement of benthic macroinvertebrates and other aquatic species. Construction may cause fish and benthic organisms in and near the intake channels to temporarily migrate from the area. Constructing the trenches for the intake and discharge pipelines from the water to the site could lead to temporary soil erosion, which may increase turbidity in nearby surface water and temporarily reduce primary productivity (as a result of reduced light penetration and the smothering of periphyton and aquatic macrophytes in the intake channel). Dredging could also cause heavy metals in sediment to be resuspended, harming aquatic organisms (NRC 2006a, Section 4.4.2).

Depending on its design, a cooling tower could occupy a portion of the bed area of the source water body. To the extent that this occurs, there could be a loss of potential habitat and displacement of the aquatic communities that reside at that location.

Contaminants, such as fuels or other fluids, accidentally released during construction can be toxic to aquatic organisms. The potential for fuel or other fluid spills that exists throughout the construction phase requires an approved Spill Prevention Control and Countermeasure Plan (NRC 2006a, Section 4.4.2).

Many construction impacts on aquatic ecosystems could be mitigated using standard industrial procedures and best management practices. Pipes would typically be buried, so there would be no permanent alteration of water flow patterns in the floodplain. A Clean Water Act §404 permit from USACE is required prior to any in-water activities associated with the construction of the intake structures.

If construction plans call for local surface water use for dust abatement, concrete batch plant operations, and potable water supply during construction, streamflow and ability to support riparian vegetation and communities could be affected; these effects may be direct or may be considered only in the cumulative impact analysis if the water is used for preconstruction activities. (Water use is a much greater concern during NPP operation.)

5.6 Socioeconomic Impacts

NPP EISs typically address non-health-related physical impacts such as noise and odors (and aesthetics) as part of the discussion of socioeconomic impacts. NRC EIS guidance also directs staff to evaluate environmental justice under the larger category of socioeconomic impacts.

5.6.1 Physical Impacts

NPP construction may include direct physical impacts to the community, including construction disturbances such as noise, odors, vehicle exhaust, dust, vibration, shock from blasting, and visual impacts of construction (NRC 2000, Section 4.4.1). These physical impacts should be addressed for plant construction, and as cumulative impacts for transmission corridors and access roads, other offsite facilities, and project-related transportation of goods and materials (NRC 2000, Section 4.4.1). The evaluation of impacts from these activities should provide context in terms of construction location relative to sensitive receptors (such as hospitals or schools), which would determine the level of impact (NRC 2000, Section 4.4.1).

5.6.2 Social and Economic Impacts

As with other types of environmental impact, an NPP EIS must separate the preconstruction-related impacts from the construction-related impacts on social and economic conditions. For any potential impacts, such as those discussed in the following paragraphs, the EIS should clearly attribute them to either preconstruction or construction.

Local population impacts associated with the construction of a new NPP will be driven by the number of construction workers who migrate into nearby communities to work at the plant. These individuals and their families (direct population), and other persons and their families who move into the area to work in jobs generated by the plant‘s presence (indirect population), add to the community‘s population totals as well. Such increases in population constitute the main driver of public service, housing, and other local economic impacts (NRC 1996, Section 4.7). The extent of the increases depends on labor availability within commuting distance of the plant, and EPA reviewers should see an assessment that is correlated with the availability of local labor. If an adequate supply of workers is available within reasonable commuting distance, few, if any workers, would choose to relocate to the site. Effects from worker influx (and their families), especially on small towns and communities, can be significant if a large percentage of the workers in-migrate. The capacity of communities to absorb an increase in population depends on the availability of sufficient resources, such as adequate housing and community services (including schools, hospitals, police, transportation systems, utilities, and fire protection) to support the influx without straining existing services. Impacts to any small community located along a commuter route (in terms of food, lodging, and gas providers, as well as traffic congestion) can also be substantial and should be considered. Depending on the existing conditions, the overall economic impact on a community may be adverse or beneficial.

> For the North Anna site, construction activities are assumed to last up to 5 years and need up to 5,000 workers for two units (NRC 2006a, Section 4.5). The peak Exelon construction workforce is estimated to be 3,150 people, a number that would be maintained for a large part of the construction period(s) at that ESP site, where construction of each new unit is estimated to occur over a 5-year period and may lag behind the preceding unit by a year or more (NRC 2006c, Section 4.5.2).

The construction plant workforce for a new NPP can include a monthly maximum of up to 5,000 workers. An important note is that no new NPPs have been licensed to operate in the U.S. since 1996, and the skilled workforce necessary to build them is very limited. Construction of multiple plants over a similar timeframe may require development of a trained national workforce that moves from plant to plant, which would increase the likelihood for effects on a local community from in-migration.

Other types of social and economic impacts resulting from construction activities, some of which may be beneficial in nature, include increased sales of private sector regional materials, products, and services; increased employment and income (local and regional levels); and higher tax revenues to local jurisdictions. Site-specific conditions would determine the nature and benefit or adversity of effects from NPP construction regarding the social or economic significance of ecological and land-use impacts, including human displacement; social structure and community cohesion; and local planning-political decision processes (NRC 2000, Section 4.4.2).

An important factor to consider in projecting beneficial economic effects specifically related to construction is that, even though increased local tax revenue during a plant‘s construction can fund projects that will ultimately benefit the local and perhaps regional economy, many of these benefits (such as improvements to schools and roads) would not be realized until many years in the future, after construction is complete. However, other beneficial effects would be more immediate, such as increased employment opportunities, higher wages, and increased demand for local goods and services.

5.6.3 Environmental Justice

> Executive Order 12898 directs federal agencies and requests independent agencies such as NRC to consider environmental justice as part of the NEPA process. The purpose of the environmental justice assessment is to identify and address, as appropriate, disproportionately high and adverse human health and environmental effects on minority and low-income populations. These populations may be present in scattered small groups or may have unusual customs, practices, or dependencies on specific resources that would be overlooked in a reconnaissance-level analysis that focuses on the majority population. As a result, it is necessary to evaluate impacts for each such population and more carefully examine unusual environmental pathways (including socioeconomic pathways) that could result in disproportionately high and adverse impacts on them [NRC 2000, Section 4.4.3].

CEQ (1997) has provided guidance for addressing environmental justice under NEPA, as has EPA (1998, 1999b). As part of its commitment to conducting environmental justice reviews, NRC issued a policy statement in 2004 setting out its position on the treatment of environmental justice issues in the agency‘s licensing and regulatory activities (NRC 2004a). The policy statement and related guidance (NRC 2004b, page D-8) charged the NRC staff with diligently investigating potential adverse environmental impacts on minorities and low-income populations, as well as to conduct even more detailed examination in situations where the percentage in the impacted area exceeds (by more than 20 percent) that of the state or the county percentage (or other appropriate comparison area) for either the minority or low-income population, or if the staff finds that the minority or low-income population percentage in the impacted area exceeds 50 percent of the total population.

Furthermore, when minority or low-income populations are identified in a potentially significant environmental impact area, NRC guidance directs that six questions be considered in determining the potential for disproportionately high and adverse effects (NRC 2004b):

- Are the radiological or other health effects significant or above generally accepted norms?
- Is the risk of rate of hazard significant and appreciably in excess of the general population?
- Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
- Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
- Are there any significant adverse impacts on a group that appreciably exceed or [are] likely to appreciably exceed those in the general population?

- Do the environmental effects occur or would they occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? [NRC 2004b, Appendix D-10]

The EIS should include a thorough discussion of impacts to environmental justice populations, commensurate with this NRC guidance. This applies to impacts from both plant construction and operation. As noted under socioeconomic impacts, the increased employment opportunities and potential for higher wages can be a beneficial impact from plant construction. However, the extent to which minority and low-income populations may benefit compared to the potential impacts has been questioned; see, for example, public comments submitted on the Draft EIS for the Grand Gulf ESP (NRC 2006b). Also, an influx of construction workers may cause an increase in rental prices which could adversely impact low-income renters. The potential for and nature of such impacts should be thoroughly addressed in the EIS.

CEQ regulations require government agencies to identify, predict, and describe reasonably foreseeable beneficial as well as adverse changes to existing conditions that may result from implementing either the proposed action or alternative actions (EPA 1998). In light of this, a thoughtful analysis of potential environmental justice issues related to the following topics should be included:

- The extent to which minority and low-income populations have benefitted from construction and operation of the previous /current generation of plants (if such information was collected and is available).

- The skill levels required for construction and the extent to which construction employment could be supplied by minorities and low-income populations.

- The locations of minority and low-income population residential areas relative to the construction site to determine the extent to which they may be disproportionately affected by the physical impacts of construction.

5.7 Radiation Exposure to Construction Workers

Radiation exposure to construction workers becomes a concern when construction takes place near or adjacent to an operating reactor. Of the 20 new NPP applications expected by NRC between 2007 and 2010 for which the site is known, 14 are proposed to be located at the site of an existing operating plant (NRC 2008b). DOE‘s roadmap to deploy new nuclear power plants also noted that the nuclear industry may benefit from recovering or completing existing sited NPPs that have been shutdown or terminated before completion (DOE 2001, Section 2.1.5). As appropriate, existing radiation conditions (whether from existing or past operations) at a site should be identified, and risks to construction workers assessed.

Construction workers may be exposed to radioactive materials that could cause them to receive doses in excess of limits for members of the public (see Section 6.5.5) when working at a site adjacent to an existing reactor. If estimates of potential worker exposure indicate that workers may be exposed to levels above the limits to the public, then construction workers must be treated as radiation workers by the licensee (or applicant), and the requirements in 10 CFR Part

20 must be followed (NRC 2000, Section 4.5). The applicant‘s environmental report should estimate, and the EIS should summarize, annual doses to construction workers due to radiation from adjacent operating unit(s) and include models, assumptions, and input data. Reference may be made to an existing analysis contained in the FSAR (NRC 1976, Section 4.4). The analysis in the EIS should present the total radiological dose to site workers from these three types of exposure (direct radiation, gaseous effluent releases, and liquid effluent releases). In accordance with CEQ‘s regulations for implementing NEPA, the EIS ―shall identify any methodologies used and shall make explicit reference by footnote to the scientific and other sources relied upon for conclusions” (40 CFR 1502.24).

> NRC‘s regulatory guide (NRC 1976) for preparing the environmental report does not specify the models or inputs to be used. In determining the radiological dose to construction workers at sites with existing nuclear facilities, the analysis will generally reference data from the current facilities‘ monitoring program, including thermoluminescent dosimeter data measuring direct radiation levels at specific locations, emissions data for atmospheric releases of radionuclides, and effluent data for liquid radionuclide releases. To estimate the occupational doses in the new NPP EIS, the exposure data would be modified, where needed, to adjust for a construction worker‘s proximity to the source compared to the measured values, and also to reflect the construction worker‘s period of exposure (usually 2,080 work-hours per year) and the duration of the construction activity.

5.8 Waste

As with other types of environmental impact, an NPP EIS must separate the preconstruction-related impacts from the construction-related impacts on waste generation and disposal. For any potential impacts, such as those discussed in the following paragraphs, the EIS should clearly attribute them to either preconstruction or construction.

If an onsite landfill is part of the proposed action, its construction would require excavation and an access road, for which the impacts to land use, water resources, and ecology are similar to the other construction impacts identified above. In addition, if plans call for an onsite landfill to become operational during the construction phase, the EIS should discuss applicable regulations, permit requirements, and monitoring programs (see Appendix A). Impacts to groundwater and surface water from leachate and impacts to wildlife should be addressed. An onsite landfill will also require transportation of waste, which could have some effect on air quality during the construction phase.

Another possible concern associated with construction waste would be disposal of contaminated sediment as a result of dredging in an area contaminated with heavy metals or other contaminants (EPA 2004, Section 1-3). The impacts would depend upon the method of dredging and the storage, treatment, and disposal of the sediment (EPA 1995). Re-suspension of contaminated sediments during dredging is discussed under water quality impacts of construction.

If nonradioactive waste is proposed for offsite disposal, the analysis should discuss the quantity of waste that will be generated in comparison to the capacity of the landfill proposed for accepting the waste. The types of nonradioactive waste potentially generated during construction of a new nuclear power plant are similar to those generated during construction of other large industrial facilities: vehicle and construction equipment maintenance waste, construction material waste, land-clearing waste, and various waste streams generated from support facilities serving onsite construction workers. Some of these may be generated by preconstruction activities, and thus only evaluated in the EIS in terms of any cumulative impacts.

5.8.1 Vehicles and Construction Equipment Maintenance Waste

Heavy earth moving equipment, concrete, and aggregate equipment will be required for construction. In addition, the onsite construction equipment requirements include very heavy lift cranes, pipe bending machines, automatic welding machines, and automatic rebar assembly machines (DOE 2005, Section 7). Maintenance and operation of construction equipment generates cleaning solvents, anti-freeze, coolants, used or soiled shop rags, unrecovered freon from air conditioners, oils and lubricants, and scrap metal parts (EPA 2007). EPA‘s ―Pollution Prevention - Environmental Impact Reduction Checklists for NEPA/309 Reviewers” (EPA 1995) provides a checklist to ensure that the adverse environmental effects of vehicle maintenance are minimized or eliminated. Compliance with hazardous material management and disposal regulations is required (see Appendix A). Impacts of onsite equipment maintenance activities can be reduced through pollution prevention techniques such as using less-hazardous parts cleaning systems, using reusable shop rags, and sending waste oil to a facility for re-refining.

5.8.2 Construction Waste

This section provides an idea of the quantities and types of materials used in constructing just the nuclear island equipment and structures for an NPP (excluding the materials required to build cooling towers, administration buildings, warehouses, water treatment systems, roads, switchyards, and other ―balance of plant” structures), which were available from a DOE report (DOE 2005, Section 3.5). DOE estimated the following bulk materials quantities for the nuclear island of a single GEN III+ unit:

- Concrete – 460,000 cubic yards (not including concrete for site preparation)
- Reinforcing steel and embedded parts – 46,000 tons
- Structural steel, miscellaneous steel, and decking – 25,000 tons
- Large bore pipe (> 2½ inch) – 260,000 feet
- Small bore pipe – 430,000 feet
- Cable tray – 220,000 feet
- Conduit – 1,200,000 feet
- Power cable – 1,400,000 feet
- Control wire – 5,400,000 feet
- Process and instrument tubing – 740,000 feet [DOE 2005, Section 3.5]

Though the material types and quantities will vary between projects, scrap from all of the above construction inputs can be anticipated. Typical construction debris consisting of concrete, asphalt, wood, metals, gypsum wallboard, floor tile, roofing material, and land-clearing debris (such as stumps, rocks, and dirt) will also be generated from construction of the ―balance of plant” facilities. EPA‘s pollution prevention checklist (EPA 1995) includes methods to minimize construction waste.

5.8.3 Temporary Construction Infrastructure

DOE (2005, Section 3.3) estimated that, for a single new nuclear power reactor unit, 800 personnel will be on-site supporting 1,600 craft labor and start-up personnel, for a total of up to 2,400 personnel during the peak construction period. Estimates of the peak personnel requirement from current applicants have been even higher than those projected by DOE, ranging up to 5,000 (see Section 5.6.2), and would depend on the specific facilities to be constructed and the construction schedule. Routine waste is generated from office facilities, personnel, bathroom facilities, and break areas. Waste can be minimized by setting up temporary facilities for recycling and using non-hazardous cleaning products to maintain temporary facilities. Waste generated in association with preconstruction activities would be assessed as a cumulative impact in the EIS. For wastes that are associated with construction activities, the EIS should evaluate the impact of their disposal, whether onsite or offsite, as described above (in subsection 5.8).

Section 5 References

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

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6. Operational Impacts

Land Use

6. Operational Impacts

- Does the EIS evaluate the potential for effects to surrounding land uses from cooling tower plumes or spray pond operations, including the impacts of salt drift, fogging, cloud cover, relative humidity, icing, and biocide drift?
- Does the EIS address the cumulative effect of long-term restrictions of land use and long-term changes in land use of the site and vicinity (including lands classified as floodplains and wetlands, prime farmland)?
- Does the EIS identify potential conflicts between federal, state, local, or Indian land use plans?
- Does the EIS discuss the proposed plant location as it relates to local land-use planning and proposed nearby future land uses, for consideration of operational impacts?
- If land use is assessed within separate construction and operation impacts chapters, the EPA reviewer should ensure that the two discussions are consistent and together present a comprehensive assessment.
- Does the EIS address the cumulative impacts on land use from new transmission line construction or upgrades that could occur during the course of operation?

Historic Resources

- If mitigation measures to protect historic properties during construction were identified, measures to extend the same protections during operation should be noted in the EIS.

Meteorology and Air Quality

- Has an effective meteorological monitoring plan been developed?
- Have air quality impacts from a cooling tower‘s plume been evaluated, including heat and moisture?
- Have routine nonradiological air emissions been quantified, including generator / boiler and worker vehicle emissions?

Water Resources

- Does the EIS include sufficient water use data and info to assess impacts of proposed project construction and operation on consumptive and non-consumptive water uses?
- Will the proposed action affect any EPA mandates, particularly water quality?
- Are potential conflicts with other (downstream) water users addressed? Have impacts on downstream water quality and shoreline been evaluated?

- Have potential impacts from contaminated sediments, if present in water bodies where dredging occurs, been considered?
- Has an effective monitoring plan been developed for thermal monitoring of surface water?
- Has an effective monitoring plan been developed for water quality and supply impacts on surface water, including permitted releases?
- Has an effective monitoring plan been developed for water quality and supply impacts on groundwater?
- Has an effective radiological monitoring plan been developed that includes surface water, groundwater, drinking water, and sediment?
- Has an effective chemical (non-radiological) monitoring plan been developed?
- Does the EIS provide assurance that the NPP will have access to a sufficient (even during periods of drought) and long-term water supply (for 40-year period of operation)?
- Are hydrological alterations from NPP operation predicted? What will the impact be on components of the aquatic environment?
- If gray water, brackish water, or wastewa2ter effluent will be used, does the EIS evaluate impacts resulting from provisions for any required treatment (such as an onsite treatment plant)?
- Does the EIS describe the plant's operational modes to adjust to water supply changes?
- If a plant is co-located with an existing nuclear plant (or coal plant that also has large water requirement), cumulative impacts on water quality from both plants should be addressed.

Ecological Resources

- Would the proposed action cause substantial damage to the ocean and coastal habitats?
- Have the effects of adverse water quality been on aquatic resources been considered?
- Have operational effects on aquatic species and habitat been considered, including effects of thermal discharges?
- Have impacts to threatened and endangered species been considered?
- Does the EIS consider impacts to ecosystems as a whole, in addition to key organisms?
- Have impacts on terrestrial habitat been considered?
- Have ecological impacts been addressed from cooling tower drift, fogging and icing, bird collisions, cooling ponds, electromagnetic fields, right-of-way management, and consumptive water uses?
- Has an effective ecological monitoring plan been developed that includes terrestrial ecology and aquatic ecology?
- Does EIS include a summary of applicable/required consultations with appropriate federal, state, regional, local, and Indian tribal agencies, including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the state fish and wildlife agency?

Radiological Impacts from Routine Operations

- Have radiological air emissions been quantified?
- Has the potential for direct radiation exposure been addressed?
- Does the EIS describe the sources of and amounts of liquid radioactive wastes?
- Does the EIS adequately describe the potential exposure pathways to support the estimates of radiation doses to members of the public?
- Does the analysis identify receptor locations, including schools, hospitals, and residences, and any locations at which plants or animals that become food for the public may be exposed to either direct radiation or contamination?
- Does the analysis quantify doses to the general population (within 50 miles) and the maximally exposed individual?
- Is the radiological risk characterization consistent with EPA, NRC, and other appropriate standards and criteria?
- Have impacts to the workers (involved and non-involved) been addressed?
- Have impacts from postulated accidents been addressed? These include design basis accidents and severe accidents, such as caused by extreme weather or a geologic/seismic event. Potential pathways to be evaluated should include air, surface and groundwater (potential tritium concerns, drinking water), food ingestion (agriculture, irrigation). NRC now also requires the consideration of design alternatives to mitigate the consequences of severe accidents.
- Has an effective radiological monitoring plan been developed that includes airborne radioiodine and particulates, direct radiation, ingestion exposure (milk, fish and invertebrates, plant-based food products), and the parameters previously identified under the Water section?
- Does the EIS evaluate the impacts of radioactive effluents on terrestrial plants and animals, and on aquatic organisms?

Waste

- Does the EIS thoroughly characterize chemical discharges, including treatment systems, concentrations, and chemicals used?
- Does the EIS describe plant systems producing mixed waste, mixed waste storage plans, mixed waste disposal plans or capabilities, and assess both radiological and nonradiological mixed waste impacts?

Socioeconomic Impacts

- Have noise impacts been identified and evaluated?
- Have visual impacts been identified and evaluated?
- Does the EIS adequately analyze the effects on local traffic patterns and transportation infrastructure?

- Have environmental justice issues been addressed?
- Does the environmental justice analysis address the following questions:
  - Are the radiological or other health effects significant or above generally accepted norms?
  - Is the risk of rate of hazard significant and appreciably in excess of the general population?
  - Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
  - Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
  - Are there any significant adverse impacts on a group that appreciably exceed or [are] likely to appreciably exceed those in the general population?
  - Do the environmental effects occur or would they occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? [NRC 2004, Appendix D-10]

Accidents

- Does the EIS describe and summarize the radiological consequences of the design basis accidents that may result in environmental releases?
- Are severe accident mitigation alternatives summarized?
- Do EISs prepared for facilities located within the Ninth Circuit include an analysis of the impact of a terrorist act?

This section targets the resources that are of greatest concern for NPP operation. Information presented is based, in part, on review and findings from Regulatory Guide 4.2, ―Preparation of Environmental Reports for Nuclear Power Stations" (NRC 1976), NRC's ―Standard Review Plan for the Environmental Reviews for Nuclear Power Plants" and its latest draft revisions (NUREG 1555: NRC 2000, NRC 2007a), and information from recent environmental reports for COL applications and EISs for ESPs (NRC 2006a, NRC 2006b, NRC 2006c). This section is also based on findings from NRC's NUREG 1437 ―Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (NRC 1996) and its supplements, which address (primarily) operation impacts associated with license renewals of existing plants. Conclusions from NUREG 1437 are referenced in recent ESP EISs. NUREG 1437 can be especially helpful for understanding impacts from operation of any proposed plants that are being co-located with an existing plant that has recently undergone license renewal.

The reviewer is also referred to Appendix H of this guidance, Useful Tools for Quick Reference, which identifies other reference sources (and website links) for impacts of NPP operation. Section 10 of this guidance, Mitigation Actions and Requirements, lists measures and controls to limit the adverse impacts of NPP operation.

There are several important points to keep in mind regarding operation of next generation NPPs:

1. **Most balance-of-plant systems will continue to have plant-specific designs.** ―Balance of plant" refers to systems other than the reactor itself and its associated systems, and generally have more influence than does reactor design on effluents and other environmental impacts –

such as cooling water intake and discharge, water treatment, and other waste handling. The system designs proposed for a specific plant will determine the potential for adverse effects, and cannot be pre-determined on a generic basis or by comparing the analysis to a plant with a different combination of system designs.

2. **Size, design, and location must be understood and considered**: The degree and extent of operational impacts depends on the number of units being proposed, the design of the units (for example, some units may require more cooling water), whether the new unit(s) is being co-located at an existing NPP site or another type of power plant (for example, coal-burning) power plant, and whether the proposal is to co-locate a new NPP where existing generation facilities are already in operation and impacts on the environment (for example, water withdrawals, commuting infrastructure, cooling towers, and others described throughout this section) already exist to some degree. However, co-location of plants could contribute to potential cumulative impacts that will need to be addressed (see Section 11).

3. **Environmental assessments for design certifications can be incorporated by reference:** NRC has prepared an EA and corresponding finding of no significant impact for each final rule for a design certification. NRC determined in each case that the rule itself would not authorize the siting, construction, or operation of the design, but would only codify the design in a rule that could be referenced in a CP, ESP, COL, or OL application.

4. **License type will influence contents of analysis:** The environmental impact analysis for a COL for a proposed plant that has already received an ESP will take form of a supplemental EIS to the earlier NRC NEPA review (ESP EIS), and will not need to present redundant analysis where conditions have not changed or no new information has been identified, and impacts thus remain the same.

5. **NEPA requires that both onsite and offsite impacts are addressed in an EIS:** NRC definitions of site and offsite are described in Section 3 of this guidance. Boundaries of offsite areas may vary by resource area. For example, health and safety impacts to the public, including minority and low-income populations, should be addressed out to a radius of 50 miles.

6. **Refer also to the construction impacts for each resource area:** For some resources, impacts from plant operation will be less than those evaluated for construction (for example, land use and some aspects of socioeconomics, where the operational workforce is much less than the peak construction workforce).

The following sections describe the primary areas of potential environmental impact from operation of a new NPP.

6.1 Land Use

The changes in land use due to siting a new NPP and its associated transmission corridors and offsite areas are described in Section 5 of this guidance document, Construction Impacts, since the construction phase is when the siting-related land use impacts begin, and the operational phase NPP siting impacts are the same. If land use is assessed within separate construction and operation impacts chapters in an NPP EIS, the two discussions should be consistent and together should present a comprehensive assessment of land use impacts from the selection of that location for the NPP.

Surrounding land uses could be affected during NPP operation if they are within the range of a plume created by cooling tower or spray pond operation. The main concern is salt drift, but cooling tower and spray pond operation also cause increased fogging, cloud cover, relative humidity, and icing over and on adjacent lands. Biocide drift also has the potential to affect vegetation, and thus land use. Salt drift can affect agricultural crops, particularly in arid environments where relatively low-quality or saline water may be used for cooling. High salt levels also occur at plants on the coasts or coastal bays. Drift deposition also has the potential to damage vegetation by soil salinization. Soil salinization is more of a problem in arid regions where rainfall is less likely to leach salt from the soil profile (NRC 2000, Section 5.3; NRC 1996, Section 4.3).

Land use in the vicinity of the plant may change as a permanent work force for the plant is established. These changes in housing and infrastructure are addressed in Section 6.7.

An EIS should address the cumulative impacts on land use from new transmission line construction or upgrades that could occur during the course of operation (NRC 2000, Section 5.5.2).

Historic Properties

An EIS for a new NPP may discuss impacts to historic properties within the Land Use impacts discussion (consistent with NRC guidance in NUREG 1555), or may present the analysis in a separate section (as has been done in some recent EISs).

Effects on historic properties are more likely to result from NPP construction than operation. Section 5.2.3 discusses the potential impact of land clearing and excavation on historic properties. If mitigation measures to protect historic properties during construction were identified, measures to extend the same protections during operation should be noted in the EIS. According to NUREG 1555, only impacts of operation that differ from those resulting from construction need to be assessed under the operational impacts discussion. The NRC guidance notes, and this guidance reiterates, that when an impact begins at the construction phase and extends through the NPP‘s operational life, it is not a different impact (NRC 2000, Section 5.1.3).

During operation, an NPP, associated structures, and transmission lines will create noise and aesthetics impacts such as a change in viewshed or cooling tower visibility (discussed further in Section 6.7.1). If these impacts detract from a historic resource (for example, if a cooling tower is in the line of site), the effect on historical resources should be evaluated. Drift from cooling towers also has the potential to contribute to degradation of historic structures, depending upon the cooling water source.

Any new ground-disturbing activities that may be conducted in the course of operation would require evaluation for effects on historic resources (NRC 2000, Section 5.1.3).

6.2 Meteorology and Air Quality

An EIS should contain adequate information on climate (wind, atmospheric stability, temperature, atmospheric moisture, severe weather, meteorological monitoring) in the environmental description (affected environment) chapter, and should describe an effective meteorological monitoring plan. Meteorological monitoring serves primarily to support assessment of impacts from radiological emissions and in the event of an unplanned release; however, meteorology also influences local dissipation of heat and behavior of non-radiological air pollutants.

The primary impacts of operation of a new nuclear unit on local meteorology and air quality would be from releases to the environment of heat and moisture from the primary cooling system (cooling towers), emissions from operation of auxiliary equipment (generators and boilers), and emissions from workers' vehicles. Transmission lines may also contribute to cumulative effects on air quality, though the effect is very minor. Gaseous radioactive emissions are discussed in Section 6.5. Nonradiological and radiological releases should be described, quantified where possible, and evaluated for potential impacts to regional air quality. If the NPP is proposed for a nonattainment area and a general conformity analysis has been conducted, a summary of its conclusions would be useful to support this discussion.

6.2.1 Cooling System

Most of the emissions from cooling towers consist of drift droplets of liquid water entrained in the air stream, which are carried out of the tower. Solids deposition (also called drift deposition) in the plant's vicinity occurs when a plume from a wet cooling tower loses buoyancy.

Various impurities are emitted in cooling tower drift, including mineral matter in the original source water and added chemicals to inhibit corrosion, control scaling and fouling, control microorganisms, and control pH (EPA 1995). Salt drift is a problem where relatively low-quality or saline water may be used for cooling, particularly at plants on the coasts or coastal bays (NRC 1996, Section 4.3.4.1.1). In addition, particulate matter less than 10 micrometers in diameter (PM_{10}) is generated from cooling towers when drift droplets evaporate and leave fine particulate matter formed by crystallization of dissolved solids. The release of PM_{10}, hazardous materials, or volatile organic compounds in the cooling tower drift can be considered as airborne emissions and, depending upon calculated emission levels, permits may be required (see Appendix A).

> Infectious thermophilic microorganisms – such as *Naegleria fowleri*, which can cause a fatal form of encephalitis – have been identified as a potential health concern as a result of workers respiratory exposure to cooling tower mists (NRC 1996, Section 4.3.6). In response to this risk, good industrial hygiene practices call for workers to use respiratory protection when cleaning cooling towers and condensers, although the Occupational Safety and Health Administration has no relevant national standard; pre-cleaning cooling water chlorination was also demonstrated to be of use (NRC 1996, Section 4.3.6).

The geographic extent of impacts from drift deposition varies. Natural draft towers release drift and moisture high into the atmosphere where they are dispersed over long distances. Local impacts are more likely to occur with mechanical draft towers because the plume is not dispersed over as great an area (NRC 1996, Section 4.3.4). Actual drift deposition measurements, which exist for only a few plants, indicate that salt deposition is not significantly above natural background levels beyond one mile from the plant cooling towers (NRC 1996, Section 4.3.1).

Ground-level fogging and icing in the site vicinity can occur when the plume from a wet cooling tower loses buoyancy. Icing of vegetation and roads can occur near mechanical draft towers when fog is present and temperatures are below freezing. Ice may also build up on transmission lines and other structures within the plant boundary (NRC 2006a, Section 5.2).

Technology and operating practice can mitigate the effects of cooling tower drift. Existing wet cooling towers at nuclear plants have drift eliminators to reduce drift (NRC 2006c, Section 5.2.1). Reduced water vapor and plume drift could result from the use of hybrid wet/dry cooling towers (NRC 2006b, Section 5.2.1). Tower maintenance and operation levels also can influence the formation of drift droplets. ―For example, excessive water flow, excessive airflow and water bypassing the tower drift eliminators can promote and/or increase drift emissions" (EPA 1995).

6.2.2 Routine Releases Other than Cooling System

Nonradiological pollutants will be emitted during the operation of auxiliary boilers, emergency generators, and onsite service vehicles. Additional standby diesel generators and auxiliary power systems for emergency power and auxiliary steam purposes that would be used on an infrequent basis would cause occasional episodes of air emissions of particulates, sulfur oxides, carbon monoxide, hydrocarbons, and nitrogen oxides.

6.2.3 Transmission Lines (Cumulative Impacts, Not Regulated by NRC)

Small amounts of ozone and smaller amounts of nitrogen oxides are produced by transmission lines (NRC 1996, Section 4.5.2). ―Gaseous effluents can be produced by corona activity on high voltage transmission line electrical conductors during rain or fog conditions, and can occur for any configuration or location. Typically, concentrations of ozone at ground level for 230 kV and lower voltage transmission lines during heavy rain are significantly less than the most sensitive instruments can measure (which is about one part per billion) and thousands of times less than ambient levels. Nitrogen oxides are even less" (EPRI 1982, as cited in PG&E 2005, Section 16.2.4).

6.3 Water Resources

Some of the most potentially damaging environmental impacts of NPPs are those on water from cooling systems. This section of this guidance document describes the different types of cooling systems and their potential water-related impacts. (Effects on aquatic ecology are discussed in Section 6.5.) Following the description of cooling system impacts, this section describes the potential effects of non-cooling system activities that may cause hydrologic alterations, affect water use and supply, or affect water quality.

6.3.1 Overview of Cooling Systems

The primary source of information in this section is NRC (1996, Sections 4.2 – 4.4). Most nuclear power (and other thermal) plants are cooled by water. A few are cooled by air, but this involves much greater cost for the cooling tower and is less efficient than wet cooling towers. Existing nuclear power plants in the U.S. today withdraw large amounts of mainly surface water to meet a variety of plant needs. The predominant water use is for removing excess heat generated in the reactor by condenser cooling. The quantity of water used for condenser cooling is a function of several factors, including the capacity rating of the plant and the increase in cooling water temperature from the intake to the discharge. The larger the plant, the greater the quantity of waste heat to be dissipated, and the greater the quantity of cooling water required.

Potential issues will vary depending on the type of cooling water system, but could include:

- water use conflicts
- altered current patterns at intake and discharge structures
- altered salinity gradients
- temperature effects on sediment transport capacity
- altered thermal stratification of lakes
- scouring due to discharged cooling water
- eutrophication
- discharge of chlorine or other biocides
- discharge of metals in waste water
- discharge of sanitary wastes and minor chemical spills
- effects of consumptive water use on riparian communities
- impairment of groundwater quality from intended or unintended releases of radioactive elements or other chemicals

The NPDES permitting program regulates cooling water intake structures, requiring under Section 316(b) of the *Clean Water Act* that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact (see ―EPA Regulations and Tools” in Appendix H for more information).

Water cooling may be with a single pass through the condenser and then discharged to river, lake, or sea at a slightly higher temperature. Or the water may be recirculated, passing through the condenser and then a cooling tower, using evaporative cooling which consumes (evaporates) some water – around 5 percent of the flow in a once-through system. The cooled water then is returned to the condenser. Cooling towers reduce the overall efficiency of a power plant by 3 to 5 percent. The cooling system of a nuclear power plant is a major mode of interaction by which nuclear power plants affect the environment.

There are three main types of water-based cooling systems, each with substantially different effects. The three cooling water system types are (1) once-through (a common mode during original plant licensing, but not expected to be as prevalent with the new plant licenses); (2) closed-cycle system that utilizes cooling towers; and (3) cooling ponds. Each system and its potential areas of impact are addressed below. Some key considerations are as follows:

Comparison of Water-Based Cooling Systems *

Consideration	Type: Once-through	Type: Closed cycle with cooling towers	Type: Closed cycle with cooling ponds
Water volume and water use conflicts	Larger volume diverted than closed cycle systems; most is returned.	Less water diverted than once-through systems due to water re-use.	
Entrainment Impingement	Higher potential due to higher withdrawal volume.	Lower potential due to lower withdrawal volume compared to once-through systems.	
Water quality	Discharge of biocides in the used water.	Discharge of blowdown with concentrated minerals	Plant discharge is to man-made impoundment, where concentrations of contaminants are higher than in natural waters. In turn, the impoundment will discharge permitted amounts contaminant-containing water to natural waters.
Thermal discharge	All waste heat is transferred to the receiving water.	Most waste heat is released from the cooling tower, with some discharged to surface water via blowdown.	All waste heat is transferred to the man-made impoundment, not to natural water systems.
Visual impacts	Localized if any.	Tower is visible for some distance	Localized (cooling ponds can be large).
Local climate and land impacts	Not significant.	Release to air can cause localized fogging, icing, salt deposition; more likely from mechanical draft than natural draft towers.	Land requirement for pond construction can be several thousand acres.

* This is a general summary only. The actual potential for impacts depends on system-specific engineering design and the site-specific hydrological and ecological characteristics.

For both once-through and closed-cycle cooling systems, the water intake and discharge structures are of various configurations to accommodate the source water body and to minimize impacts to the aquatic ecosystem. The intake structures are generally located along the shoreline of the waterbody and equipped with fish protection devices. The discharge structures are generally of the jet or diffuser outfall type and are designed to promote rapid mixing of the effluent stream with the receiving body of water. Biocides and other chemicals used for corrosion control and for other water treatment purposes are mixed with the condenser cooling water and discharged from the systems.

Most closed-cycle systems use cooling towers, although some use a cooling lake or canals for transferring heat to the atmosphere. In closed-cycle systems, the cooling water is recirculated through the condenser after the waste heat is removed by dissipation to the atmosphere, usually by recirculating the water through large cooling towers. Recirculating cooling systems consist of either natural draft or mechanical draft cooling towers, cooling ponds, cooling lakes, or cooling canals. Because the predominant cooling mechanism associated with closed-cycle systems is evaporation, most of the water used for cooling is consumed and is not returned to a water source. Therefore, water consumption is a big concern in terms of potential conflicts with other water uses in the area.

Other systems that have been considered include dry systems and hybrid wet/dry cooling towers.

6.3.1.1 Once-Through Cooling Systems

In a once-through cooling system, circulating water for condenser cooling is drawn from an adjacent body of water, such as a lake or river, passed through the condenser tubes, and returned at a higher temperature to the adjacent body of water. The waste heat is dissipated to the atmosphere mainly by evaporation from the water body and, to a much smaller extent, by conduction, convection, and thermal radiation heat. Note that while once-through cooling returns the water after use, it diverts a larger volume of water for plant use than closed cycle. Potential impacts from entrainment and impingement are higher with once-through cooling systems than closed cycle systems.

> Once-through cooling systems can affect the environment by withdrawing a large amount of water, heating it, adding biocides, and discharging it back to the receiving body with an added load of heat and chemical contaminants. The main issues associated with plants using this system include effects on aquatic organisms due to changes in water quality (thermal discharge effects and chemical contaminants), entrainment, and impingement; water use conflicts; and effects on surface water quality, hydrology, and use.

The operation of a once-through cooling system alters water quality primarily through the discharge of heat and chemicals to a receiving body of water. The largest volumes of discharge are associated with the main condenser cooling system. The amounts of heated effluents from such a system can be large: a nuclear power plant with a once-through cooling system discharges water at about 736,000 gallons per minute per 1,000 MWe with a temperature increase of 10 ^{o}C (18 ^{o}F).

Effects on Surface Water Quality, Hydrology, and Use

The operation of once-through condenser cooling systems can result in associated hydrologic changes, including altered current patterns of intake and discharge structures, altered salinity gradients, and altered thermal stratification of lakes. Water quality effects can include water temperature increases (including the afore-mentioned altered thermal stratification of lakes), temperature effects on sediment transport capacity, scouring, lowered dissolved oxygen concentrations, eutrophication, and the discharge of biocides, sanitary wastes, and heavy metals. Some of the specific causative agents for water quality issues associated with chemicals are discharges of chlorine or other biocides, small volume discharges of sanitary and other liquid wastes, chemical spills, and heavy metals leached from cooling system piping and condenser tubing. In general, NRC has shown through extensive study and monitoring at existing plants that the effects of chemical discharges appear to have been largely controlled through existing permit processes and/or individual plant problems have been adequately mitigated. Intake and discharge effects are regulated through an NPDES permit. Regulatory concern about toxic effects of chlorine and its combination products, as well as operating experience with control of biofouling, has led many plants to eliminate the use of chlorine or reduce the amount used. Some power plants use mechanical cleaning methods, or do not need to clean at all. Others chlorinate the condenser cooling water but can isolate certain portions for treatment, thereby allowing dilution to reduce the concentration of chlorine in the discharge. Mitigation has also proven effective for heavy metal release issues, such as by replacing copper alloy condenser tubes with another material such as titanium. Monitoring has not revealed a continuing problem with accumulation of heavy metals at existing plants today.

Consumptive uses remove the water from a stream or river and may impact in-stream and off-stream beneficial uses. In areas experiencing water availability problems, nuclear plant consumption may conflict with either existing or potential downstream municipal water use as well as with in-stream water uses. A shift in human population distribution and associated changes in demand for water could have important implications for the continued supply of cooling water for power-generating facilities.

The discharge of heated effluent to a body of water may encourage the growth of thermophilic microorganisms, some of which can cause disease in humans. NRC (1996, Section 4.3.6) listed some microorganisms whose populations might be enhanced as a result of thermal discharges, including the enteric pathogens *Salmonella* sp. and *Shigella* sp., *Pseudomonas aeruginosa, Legionella* sp., free-living amoebae of the genera *Naegleria* and *Acanthamoeba,* and the thermophilic fungi. Site-specific factors and the use (particularly if contact recreation is allowed) of a water body will determine the potential for humans to come into contact with any such microorganisms. The amoeba *Naegleria fowleri*, which lives in soil, is of particular concern, since it can cause a fatal form of encephalitis once it enters through the nasal passages; recent fatal incidents following recreational exposure not associated with NPP thermal discharges have brought increased public attention to the risk posed by this microbe. NRC (1996, Section 4.3.6) stated that ―heavily used lakes and other fresh bodies of water may merit special attention and possibly routine monitoring for *N. fowleri*.”

6.3.1.2 Closed-Cycle Cooling System with Cooling Tower

Mechanical and natural draft wet cooling towers transfer waste heat to the atmosphere primarily by evaporating water. Natural draft towers are generally up to 520 feet in height, whereas mechanical-draft towers are generally less than 100 feet tall. Because of the large cooling capacity of natural draft towers, only one such tower is required for each reactor unit; but two or more mechanical draft towers are required for equivalent cooling.

Natural draft cooling towers use buoyancy via a tall chimney. Warm, moist air is less dense than drier air at the same temperature and pressure. Therefore, it rises in comparison to the dry, cooler outside air. This rising moist air buoyancy produces a current of air through the tower.

Mechanical draft cooling towers use power-driven fan motors to force or draw air through the tower.

Natural draft towers release drift and moisture high into the atmosphere where they are dispersed over long distances. Local impacts are more likely to occur with mechanical draft towers because the plume is not dispersed over as great an area. Icing of vegetation and roads can occur near mechanical draft towers when fog is present and temperatures are below freezing. Actual measurements of drift deposition have been collected at only a few plants. These measurements indicate that, beyond one mile from the plant cooling towers, salt deposition is not significantly above natural background levels.

Most of the water lost from a cooling tower escapes to the atmosphere as water vapor in the exhaust flow. About 10 percent of the vapor condenses after release, forming the visible part of the plume leaving the tower. Drift droplets of cooling water are also entrained in the air stream inside the tower and escape directly into the atmosphere. A particulate solid drift material remains after droplet evaporation. The drift contains varying amounts of salts, biocides, and microorganisms.

Effects on Surface Water Quality, Hydrology, and Use

Source water requirements for closed-cycle cooling systems are significantly less than those of once-through systems, but can still be substantial. Loss through consumption and evaporation can represent a substantial proportion of the flows in small rivers. Plant access to a sufficient (even during periods of drought) and long-term water supply (for 40-year period of operation) will be critical. Potential conflict with other (downstream) water users is another important area of potential concern. Off-stream water uses, such as power plant consumption, must be regulated to ensure that important instream uses, use as aquatic habitat, recreational uses, and drinking water supply are not compromised. Intake and discharge effects are regulated through an NPDES permit.

Although cooling towers are considered to be closed-cycle cooling systems, concentration of dissolved salts in the system water – which results from evaporative water loss – requires the discharge of a certain percentage of the mineral-rich stream (blowdown) and its replacement with fresh water (makeup water). The quantities of blowdown are relatively small compared with the discharges from once-through systems, typically on the order of 10 percent. Water quality impacts could occur from the elevated temperatures of the blowdown or from the concentration and discharge of chemicals added to the recirculating water to prevent corrosion and biofouling and to regulate pH. The concentration of total dissolved solids in the cooling tower blowdown averages 500 percent of that in the makeup water, a concentration whose dilution depends on the volume of the receiving water.

6.3.1.3 Closed Cycle with Cooling Ponds

Power plants that use cooling ponds comprise a unique subset of closed-cycle systems in that they operate as once-through power plants (with large condenser flow rates) that withdraw from and discharge to relatively small bodies of water created for the plant. Cooling ponds reduce the heat load to natural bodies of water from power plant operations without the construction and operational expenses of cooling towers. The natural body of water is not relied on for heat dissipation but is used as a source of makeup water to replace that lost to evaporation and as receiving water for discharges from the cooling pond. Typically, a cooling pond is a man-made impoundment that does not impede the flow of a navigable system and that is used primarily to remove waste heat from condenser water prior to recirculating the water back to the main condenser. The surface areas of the cooling ponds associated with this type of cooling system may range from over 1,500 to over 7,000 acres. Power plants sited on cooling ponds do not have unique effluents or emissions. They are the same as those considered for once-through cooling systems. Intake and discharge effects are regulated through an NPDES permit.

Accelerated evaporation of water from a cooling pond produced by thermal loading from the power plant increases the concentration of total dissolved solids. Concentrations of total dissolved solids in cooling reservoirs average about 1.8 times those in the makeup waters. Contaminants may also accumulate in the pond water and sediments. Accumulation of constituents such as metals (copper or zinc) and chlorinated organic compounds in water, sediments, and aquatic biota are all potential issues for plants located on cooling ponds.

Effects on Water Quality and Use

Probably the most important change in the consideration of water use impacts since the initial licensing of most nuclear plants (that rely on off-stream ponds or lakes as cooling devices) has been the increased emphasis on in-stream flow for preservation of aquatic habitat, riparian (streamside) habitat, and associated biota. Nuclear power plants that withdraw makeup water for cooling ponds from small bodies of water may need to curtail operation during drought periods or may experience future conflicts with other water users.

A water quality issue associated with operation of a cooling pond is the potential alteration of the quality of both pond and natural receiving waters as a result of the addition and concentration of a variety of chemicals (used to control biofouling and inhibit scaling and corrosion in the condenser tubing). Discharges of heat and chemical contaminants are limited by NPDES permits issued for the plant. Another potential concern is the overall increase in total dissolved solids and the concentration of heavy metals. Risks posed by thermophilic microorganisms to humans may be a consideration, depending on accessibility of the cooling pond or lake; see discussion in Section 6.3.1.1.

6.3.1.4 Dry Air and Hybrid Cooling Systems

Wet cooling towers or simply cooling towers operate on the principle of evaporation; these natural and mechanical draft systems were described previously in Section 3.0 of this report.

Dry coolers operate by heat transmission through a surface that divides the working fluid from ambient air, such as through finned tubes. They rely mainly on conduction and convection to accomplish heat transfer instead of evaporation. Dry coolers have historically not been used in the U.S. due to high capital costs and poor performance during hot weather (Najjar et al. 1979). Advantages of a dry cooling system include no evaporative water loss (and avoiding associated effects such as fogging, icing, and drift deposition).

A combination wet/dry cooling system can also be employed, which removes part of the heat load in both ways described above, decreasing make-up water requirements and the external impacts of evaporation while somewhat mitigating the negative factors that a 100-percent dry cooling system would entail.

> A combination wet/dry system has been proposed for use in one unit of the two proposed new units at the North Anna site, where the wet system would be used during periods of water surplus in the lake serving as the water source, and combined wet/dry cooling would be used when lake levels fall below a certain threshold (NRC 2006a, Section 3.2.2). For the second proposed unit at North Anna, a completely dry cooling system using an air-cooled heat exchanger has been proposed, which would require a relatively small amount of makeup water (about one gallon per minute) that would obtained from the first proposed unit‘s intake, would generate no blowdown releases to surface water, and no releases to air with the exception of periodic nonradiological emissions from auxiliary boilers and generators.

6.3.2 Hydrological Alterations

“Ecosystems possess natural hydrologic patterns that provide water for organisms and physical structure for habitats. This cycle of water is also the vehicle for the transfer of abiotic and biotic materials through the ecosystem. The natural hydrologic patterns of an ecosystem include the magnitude, frequency, duration, timing, and rate of change (flashiness) of water flow” (EPA 1999, Section 5). The EPA document “Considering Ecological Processes in Environmental Impact Assessments” (EPA 1999, Section 5) includes a section on hydrologic patterns and is a useful tool for understanding hydrological alterations, potential resulting impacts, and mitigation methods.

The extent of hydrological alteration depends on site-specific characteristics as well as cooling system design. Determining a natural water system‘s tolerance for hydrological alterations requires assessing various indicators and parameters to determine ecosystem influences (Swanson 2002).

When identifying impacts from operation of an NPP, an EIS should project the hydrological alterations that the NPP operation will cause, and then also assess the impacts of those changes on components of the aquatic environment.

Cooling systems will probably cause the most significant hydrological alterations over the course of plant operation. However, construction and maintenance activities can also cause hydrological alterations. Section 5.4.1 discussed numerous construction activities that can alter hydrology. Many of these alterations will not be further changed during plant operation; however, new construction or maintenance involving any of these activities, over the course of plant operation, on the plant site or in offsite areas, would need to be assessed (for example, new or improved roads, bridges, building foundations, canals, or ponds) (NRC 2000, Section 5.2.1).

During operation, hydrological alterations can be caused by maintenance dredging and permanent dewatering (for plants in low-lying areas). Dredging will alter physical characteristics of water bodies and dewatering can depress the water table in the vicinity and possibly change the direction of groundwater flow and the available capacity of local wells. Operational activities can alter erosional, depositional, and sediment transport characteristics and result in physical effects, such as beach erosion and increased turbidity, that are likely to affect other water users.

Operational activities may disrupt natural processes that would occur in the absence of plant operation. Operational activities can alter hydrologic geometries, flow and circulation patterns, and mixing processes. Physical changes resulting from intake system operation may include shoreline erosion, bottom scouring, induced turbidity, and silt buildup (NRC 2000, Section 5.3.1).

For sites using active dewatering systems (systems in which groundwater is pumped from the aquifer), the same bounding conditions apply as for groundwater use in potable and service water systems. That is, for operational dewatering systems that do not exceed 0.0063 cubic meters per second (m^3/s) (100 gallons per minute – gpm), impacts would be considered small. Because the cone of depression would not extend beyond the site boundaries, no mitigation measures beyond those implemented during the current term license would be warranted. For plants that withdraw more than 0.0063 m^3/s (100 gpm), the amount of impact caused by the groundwater withdrawal cannot be determined generically, and would require site-specific analysis (NRC 1996, Section 4.8.1).

> ―Because water quality and water supply are interdependent, changes in water quality must be considered simultaneously with changes in water supply. In *Jefferson County PUD #1 v. Department of Ecology*, the U.S. Supreme Court granted the states additional authority to limit hydrological alterations beyond the states‘ role in regulating water rights" (NRC 2000, Section 5.3.2.1).

6.3.3 Water Use and Supply

While cooling systems may have the largest impact on both non-consumptive and consumptive water use, station operation will also use water for sanitary systems, radioactive waste and chemical waste systems, and process and service water systems (NRC 2000, Section 5.2.2; NRC 1976, Section 3.3). NPPs may obtain water for these purposes from municipal water systems, lakes, rivers, or groundwater supplies. As stated above, the amount of water use depends on the cooling system design, but level of environmental impact that results depends on many other plant- and site-specific conditions. The following points are important to consider in evaluating the impacts of water use:

1. Water requirements will vary with design and possibly water quality. Less water may be required for plants using clean fresh source water than for those using brackish or polluted water.

2. Water requirements for plant cooling are significant and it will be important that the EIS clearly demonstrates whether water withdrawals will adversely affect current and future uses downstream (for example, drinking water, recreation, agriculture, or irrigation). All competing uses for water supply should be considered.

3. Site-specific conditions should be described adequately to document that the required water is currently available or will be available to support operation of the NPP as proposed. This may require adequate groundwater resource data and/or surface water flow (historical flow) data to compare with plant requirements. Occasional or recurring drought situations in some regions, whether due to climate change or increasing population demand, must be

considered. The EIS may need to demonstrate proof of agreements with state, county, or other appropriate authority that the applicant does have the necessary water rights.

4. The EIS should also show that water requirements can be met for the life of the plant (40 years or more).

5. If a groundwater source is a designated sole source aquifer, the EIS should evaluate whether the proposed use would lower the water table and, if so, whether this could induce infiltration into the aquifer of water of lesser quality (including saltwater intrusion in coastal areas); this is a specific issue that EPA is responsible for reviewing under the Safe Drinking Water Act.

6. Combinations of water sources may be identified in an EIS. Some proposed NPPs will depend upon one source. Others may propose multiple sources, with one as a primary source and others as backup sources. A plant may need several sources in combination to provide the necessary supply (for example, surface water, groundwater, wastewater effluent). All possible sources should be identified and the impacts on water supply from using each source need to be addressed in the EIS.

7. Some proposals may call for using gray water or brackish water or wastewater effluent (water that needs to be treated before it can be used). If so, the impacts resulting from provisions for this treatment (for example, construction of an onsite treatment plant), if it is the responsibility of the applicant, should be addressed in the EIS. Those applicants using city wastewater/effluent that they get directly from an existing city/county wastewater treatment plant would not be required to evaluate an existing plant operated by a permitted operator (such as for city water). However, if a new pipeline was required to get water to the plant, the effects of its construction would need to be addressed.

8. For plants that withdraw groundwater for potable and/or service water systems, the rate of withdrawal is of greater concern if it causes a cone of depression that extends beyond site boundaries. In this case, the effects on the water supply of neighboring users must be evaluated (NRC 1996, Section 4.8.1).

9. The plant‘s operational modes to adjust to water supply changes should be described (NRC 2006b, Section 3.2.2).

6.3.4 Water Quality

Cooling system operation is the main source of potential impacts to surface water quality from NPP operation, as a result of thermal and chemical discharges. Impact discussions relative to thermal discharges may rely heavily on compliance with NPDES permits, whose requirements should help address any potential impacts from cooling water system on water quality (such as thermal discharges). Surface water and ground water quality regulations vary state to state and for specific water resources.

In addition to direct effects on the thermal or chemical nature of the water column, contaminated sediments may be present in water bodies where dredging occurs. If a plant is co-located with an existing nuclear plant (or coal plant that also has large water requirement), cumulative impacts on water quality from both plants should be addressed.

Alteration of groundwater quality in shallow unconfined aquifers may occur at plant sites that use cooling water. Cooling ponds, which have a large surface area, have higher concentrations (than makeup water) of (1) total dissolved solids, due to evaporation; (2) heavy metals, due to contact of cooling water with plant equipment; and (3) chlorinated organic compounds used to prevent biofouling of equipment. Water seeping from these ponds commingles with underlying shallow groundwater and produces a groundwater mound. As plant operation continues, groundwater quality at points near the site may approach the quality of the cooling pond water. Cooling pond liners are not used in the nine plants in operation that have cooling ponds (NUREG 1437). None of the ESPs or COLs approved or in review by NRC as of the date of this report propose the use of cooling ponds. The cost and maintenance of a liner this size would not be cost-effective, nor generally indicated by the cooling pond‘s function of simply dissipating heat. In addition, if a natural system is used, the benthic ecosystem would be adversely impacted by a liner.

Impairment of groundwater quality could occur at estuary and ocean site facilities that withdraw groundwater for any purpose. Long-term pumping of groundwater from coastal plain aquifers by industrial and municipal facilities has contributed to saltwater intrusion in some areas of nearly every Atlantic and Gulf Coast state.

Groundwater quality could also be impaired at inland sites where groundwater may be replaced by poorer quality river water through induced infiltration.

The EIS should describe effective monitoring plans for the following:

- Thermal monitoring of surface water.
- Water quality and supply impacts on surface water, including permitted releases.
- Water quality and supply impacts on groundwater
- Chemical (non-radiological) monitoring

6.4 Ecological Impacts

The EIS should consider impacts to ecosystems as a whole, in addition to key organisms. The EPA guidance, ―Considering Ecological Processes in Environmental Impact Assessments" (EPA 1999, Introduction), provides information to EPA offices on how to incorporate ecological considerations into the preparation and review of environmental impact assessments. This guidance explains how to use an ecosystem approach, consistent with an earlier CEQ guidance (CEQ 1993). The guidance states that EISs, when relevant, should take into account the interconnectedness of processes within ecosystems. Analyses should capture all aspects of biological diversity, especially the interactions within and among ecosystems rather than simply focusing on a single species or a familiar habitat.

6.4.1Terrestrial Ecosystems

Adverse impacts on terrestrial organisms or ecological systems from NPPs generally result from loss or modification of habitat, release of minerals or toxic chemicals into the environment, and direct destruction of biota. Impacts to terrestrial ecosystems can be expressed at the level of the individual organisms or at the system level. “Examples of effects on individual organisms include death, reduction of health or vitality, accumulation of toxic substances, and alteration of reproductive success. Examples of ecological system effects include changes in birth or death rates, changes in toxic element concentrations throughout entire food webs, and changes in population size, habitat, or community structure” (NRC 1977, Section B). Some general points to consider in reviewing terrestrial ecosystems analyses in NPP EISs are (in addition to the points made for construction impacts):

- Impacts on terrestrial habitat (destruction, loss of vegetative cover) should be considered.
- An effective ecological monitoring plan should be developed that includes terrestrial ecology.
- The EIS should include a summary of applicable/required consultations with appropriate federal, state, regional, local, and tribal agencies, including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the state fish and wildlife agency.

Nonradiological operational impacts to terrestrial ecology are described in the following paragraphs:

- Cooling tower drift: Exposure to salts from drift can affect the productivity of nearby agricultural crops, as well as the health of natural plant communities. “In arid environments, competition for water resources can result in the use of relatively low-quality or saline water for cooling, and the potential for drift-induced damage to surrounding vegetation may be greater” (NRC 1996, Section 4.3.4.1). Salts from cooling towers are deposited on vegetation by wind-driven impaction, droplet and particulate fallout, and rainfall. “In high-salt environments such as a windy seashore, impaction is usually the most important process, delivering 10 times more salt to vegetation than does fallout. Increasing wind speeds and salt concentrations increase impaction, hence increasing vegetation injury” (NRC 1996, Section 4.3.4.1). Plants damaged by salt drift may have acute symptoms, chronic effects, or increased susceptibility to disease and insect damage. Drift deposition also has the potential to damage vegetation by soil salinization. “Soil salinization does not usually occur in areas where rainfall is sufficient to leach salts from the soil profile” (NRC 1996, Section 4.3.4.1). But in arid regions, cooling tower drift has the potential to increase soil salinity and adversely affect native and agricultural plants.
- Fogging and icing: Vegetation within the area of the plume can be impacted by ice or fogging conditions from cooling towers or spray pond operation, which differ from the conditions to which it is acclimated.

- Bird collisions: There is potential for bird mortality resulting from collisions with natural-draft cooling towers. Noise and air movement from the tower may decrease likelihood of bird collisions. Collisions may increase if the plant is located in a major migratory bird concentration area (NRC 2006a, Section 5.4.1.3).

- Cooling ponds: Potential impacts during plant operation include exposure of terrestrial habitats near the ponds to increased levels of humidity, icing, and fog. “Waterfowl and other wildlife that use the ponds may be exposed to increased levels of dissolved solids and other contaminants released from the power plant” (NRC 1996, Section 4.4.4). Any of these conditions can affect individual animals or plants, and also would be of greater concern if they are present at levels that threaten the stability of local wildlife populations or vegetation communities (NRC 1996, Section 4.4.4).

- Electromagnetic fields (in terms of cumulative impacts only): Minor damage to plant foliage and buds can occur in the vicinity of strong electric fields. Electromagnetic fields have been demonstrated to affect honeybees in hives under transmission lines. Small birds and mammals living in rights-of-way corridors and birds (mainly raptors) that nest in transmission line towers may have chronic exposures. Larger animals and livestock generally have only short-term exposure since they inhabit larger areas, but are exposed as they pass beneath the lines or, for birds, as they fly by the lines (NRC 1996, Section 4.5.6.3).

- Right-of-way management (in terms of cumulative impacts only): Maintaining transmission corridor rights-of-way includes mowing and herbicide use, both of which may pose risks to individuals and local populations of small animals. Where corridors cross particularly important wildlife habitats, impacts may be of greater concern.

- Consumptive water use: If the amount of water in a stream is reduced, it can adversely impact riparian vegetation and associated animal communities by reducing the water available for plant growth, maintenance, and reproduction. Dewatering can decrease the width of the riparian corridor, change species and community diversity, increase susceptibility to flooding, change tree canopy cover, decrease the area covered by trees, and lower seedling densities. Dewatering effects are most apparent in the arid and semi-arid western U.S. “In the eastern U.S., dewatering effects generally involve more subtle changes in community composition because of higher precipitation, humidity, and soil moisture and the lower water stress conditions that prevail” (NRC 1996, Section 4.3.2.1).

6.4.2 Aquatic Ecosystems

The experience of existing plants indicates that their operating impacts on aquatic biota appear to be more a function of the unique characteristics of the NPP, its cooling system, and its environment. Conclusions about the severity of impacts can only be made on a site- and plant-specific basis.

Potential aquatic ecology issues from plant operation could include:

- impingement of fish
- entrainment of fish, early life stages, phytoplankton, and zooplankton
- thermal discharge effects, cold shock, thermal plume barrier to migrating fish
- distribution of aquatic organisms
- premature emergence of aquatic insects
- stimulation of nuisance organisms‘ populations
- losses from predation, parasitism, and disease among organisms exposed to sublethal stresses
- gas supersaturation
- low dissolved oxygen in discharge
- accumulation of contaminants in sediments or biota
- Water loss from evaporation can have substantial effects on a small stream, such as reduced habitat for fish and aquatic invertebrates.

An NPP EIS should provide a summary of applicable/required consultations with appropriate federal, state, regional, local, and tribal agencies, including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the state fish and wildlife agency.

Depending on cooling water supply source, many of the aquatic ecology concerns may be negligible. For example, if groundwater is used as cooling water (or gray water from municipalities), entrainment and impingement would no longer be a concern. Or if discharge will be to groundwater rather than surface water, thermal discharge impacts on aquatic ecology would also no longer be a concern.

The following paragraphs summarize the types of impacts on aquatic ecosystems that are frequently associated with NPP operation, which are largely associated with the plant‘s cooling water system.

6.4.2.1 Aquatic Ecosystem Impacts from Cooling Systems

Thermal Discharge Effects

Thermal discharge or cold shock, both resulting from heated plant effluents, can cause mortality to fish and other aquatic organisms. High water temperatures near effluent discharge structures can kill aquatic organisms. Research has determined the temperatures causing lethality and various other effects for many species, and resulting regulations have made use of these data (NRC 1996, Section 4.2.2.1.4). Each permitting state has developed mixing zone criteria and thermal discharge limits for steam-electric power plants. A facility may be eligible for a thermal variance under Section 316(a) of the Clean Water Act. To obtain a Section 316(a) thermal variance from water quality standards, the facility must demonstrate that the alternative effluent limitation desired by the discharger, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of a balanced indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made.

Heated effluents can affect aquatic populations in other ways too, by altering their distribution, growth, or movements. Changes in benthic community composition such as losses of seagrass or other macrophytes can alter the habitat available to aquatic animals. Warm water can increase the metabolic rates of aquatic biota. In the absence of adequate food supplies, elevated metabolic rates can lead to a poor condition of the fish inhabiting heated areas. Other potential concerns include:

- Impacts of thermal discharges on geographic distribution of aquatic organisms
- Premature emergence of aquatic insects
- Gas bubble disease
- Low dissolved oxygen in plant discharge
- Losses from parasitism, predation, and disease
- Stimulation of nuisance organisms

Many NPPs use mitigation measures to reduce the potential for thermal discharge effects, such as lowering effluent temperature before discharge to natural waters (for example, with cooling ponds) or by enhancing rapid mixing and heat dissipation (through high-velocity jet diffusers).

At a minimum, the EIS should list of representative important species that might be impacted by the thermal discharge plume. The EIS should also include results from predictive studies designed to determine the impact from the thermal loading on water quality (that is, on dissolved oxygen concentrations) and on any sensitive spawning areas that might be impacted by the thermal plume. Such predictive studies should consists of thermal modeling performed to capture the impacts over an annual period, as well as a literature research to present the temperature tolerant range for all life stages of organisms identified as representative important species.

> *Representative important species* are those species that represent, in terms of their biological requirements, a balanced indigenous community of shellfish, fish, and wildlife in the body of water into which the discharge is made. Specifically included are those species that are: 1) commercially or recreationally valuable, 2) threatened or endangered, 3) critical to the structure and function of the ecological system, 4) potentially capable of becoming localized nuisance species, 5) necessary in the food chain for the well-being of species determined in 1) through 4), or representative of the thermal requirements of important species but which themselves may not be important.

Cold Shock

Cold shock occurs when organisms that have been acclimated to warm water (such as in a discharge canal in winter) are exposed to sudden temperature decreases when artificial heating ends. Such situations may occur when a single-unit power plant suddenly shuts down in winter or when winds or currents shift a thermal plume that was occupied by fish or benthic invertebrates seeking warm water. As with heat effects, the conditions that can lead to cold shock are relatively well understood and can be mitigated if needed.

Entrainment

Water that is withdrawn from power plant cooling carries a variety of aquatic organisms. Those fish and shellfish or their eggs that are small enough to pass through the debris screens in the intake pass through the entire cooling system, and are exposed to heat, mechanical and pressure stresses, and possibly biocides before being discharged to the receiving water. This process, called entrainment, may affect phytoplankton, zooplankton, planktonic larval stages of benthic organisms, and fish eggs and larvae. The effects of entrainment on aquatic resources were considered by NRC at the time of original licensing and are periodically reconsidered by EPA or state water quality permitting agencies in the development of NPDES permits. Most NPPs have been required to monitor for entrainment effects during the initial years of operation.

Impingement

Aquatic organisms that are drawn into the intake with the cooling water and are too large to pass through the debris screens may be impinged against the screens. Mortality of fish that are impinged is high at many plants because impinged organisms are eventually suffocated by being held against the screen mesh, or are abraded, which can result in fatal infection. Impingement can affect large numbers of fish and aquatic invertebrates. Larger organisms may be killed or injured when they are trapped against screens at the front of an intake structure. Operational monitoring and mitigative measures have allayed some concerns about population level effects from entrainment and impingement at most plants.

6.4.2.2 Effects of Specific Cooling Systems

Once-Through Cooling Systems

Temperatures high enough to kill organisms are found in the cooling water systems, often in the area nearest the effluent discharge structure. Despite existing research and regulation, thermal discharge effects (and related potential for cold shock) continue to be an issue, mostly at once-through cooling systems. The potential for cold shock could be reduced by changing to a closed cycle cooling system.

Once-through cooling systems with their large water intake volumes have a greater likelihood of causing entrainment and impingement, although operational monitoring and mitigative measures have allayed some concerns about population-level effects from these conditions. Typically, power plants with once-through cooling water systems have higher entrainment and impingement impacts than power plants with closed-cycle cooling water systems. The EPA issued a final rule in December 2001 on the design of intake structures for new power plants. These rules encourage the use of close-cycle systems, and all of the new licenses are likely to be this type, which are more limiting with respect to intake water capacities and velocities, and incorporate specific intake screen designs to reduce entrainment and impingement losses.

Closed-Cycle Cooling System with Cooling Tower

While closed cycle cooling systems typically have less of a problem with entrainment and impingement than once-through systems, these can still present a concern when a sensitive resource is found in the area, such as a threatened or endangered species. The need to replace water loss from evaporation with make-up water can have substantial effects on a small stream, such as reduced habitat for fish and aquatic invertebrates.

Cooling Ponds

Elevated levels of chemical constituents (such as copper) are of potential concern for aquatic biota. Aquatic biota could also be affected by impingement, entrainment, and thermal discharges (similar to once-through cooling).

6.5 Radiological Impacts of Normal Operation

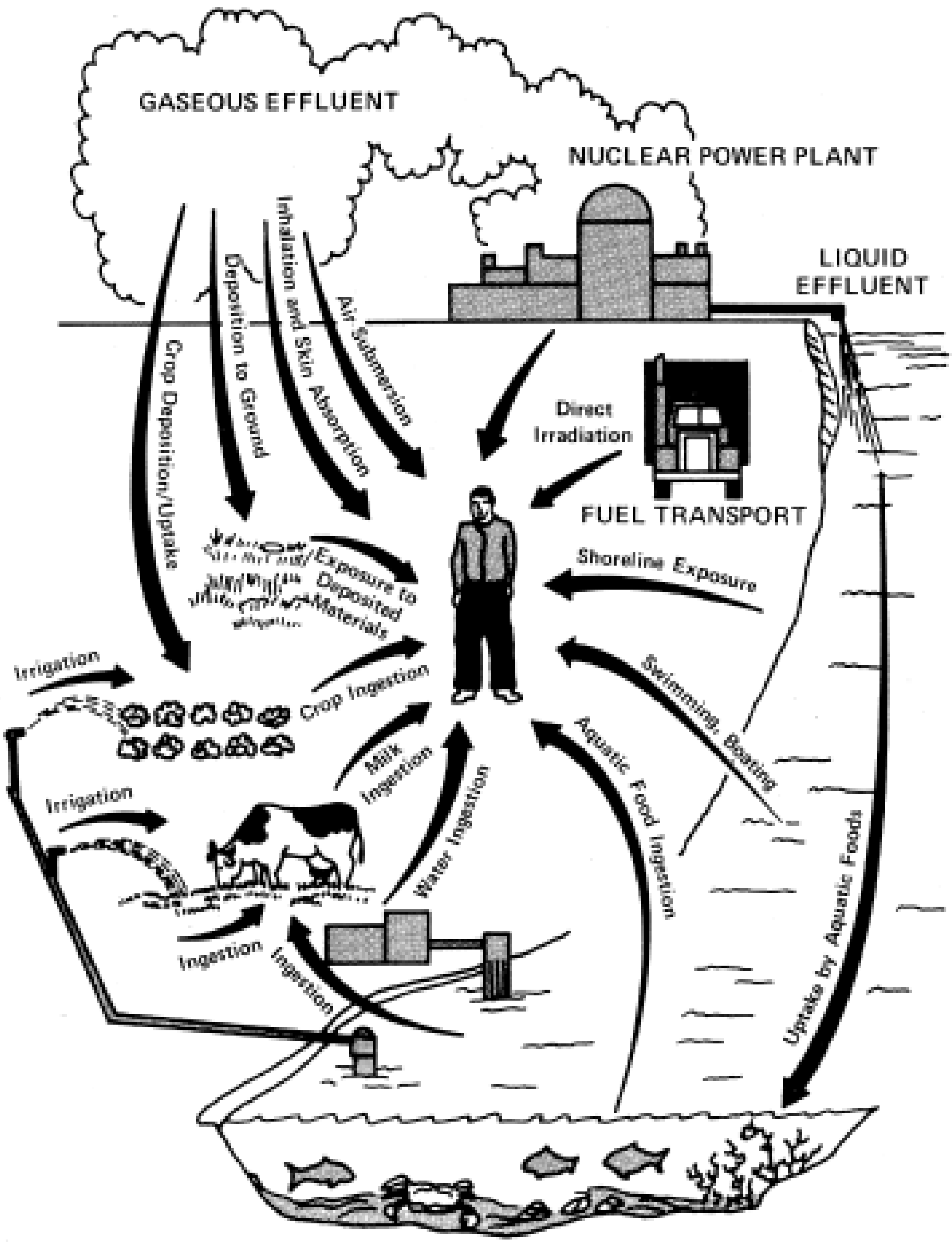
The impacts of radiological emissions have been assessed in the numerous EISs prepared for existing NPPs. In general, because of the large exclusion area surrounding a nuclear plant and the extensive safety features of the plant, potential health concerns to workers and the public are low during routine operations. Impacts in the event of an accident would be a larger concern, where the consequences of accidental atmospheric releases, fallout onto open bodies of water, releases to ground water are severe but have a low probability of occurring (NRC 1996, Section 5.3). EISs for NPP licensing also assess activities that occur outside of routine operations, including the uranium fuel cycle, solid waste management (including transportation), and plant decommissioning. This section focuses on routine operation releases to air and water. Accidents are addressed in Section 6.8, and radiological waste is discussed under nuclear fuel cycle impacts in Section 8 of this guidance document.

> Radioactivity in the reactor coolant is the source of gaseous, liquid, and solid radioactive wastes at light water reactors. During the fission process, a large inventory of radioactive fission products builds up within the fuel. Virtually all of the fission products are contained within the fuel pellets. —The fuel pellets are enclosed in hollow metal rods (cladding), which are hermetically sealed to further prevent the release of fission products. However, a small fraction of the fission products escapes the fuel rods and contaminates the reactor coolant. The primary system coolant also has radioactive contaminants as a result of neutron activation" (NRC 1996, Section 2.2.4.1).

As an element in the cumulative impacts analysis, the EIS may address exposure to the electromagnetic fields generated by transmission lines. Such exposure has not been conclusively shown to cause human health effects, nor has a plausible biological mechanism by which such exposure could cause disease been established. However, interference caused by electromagnetic fields with medical devices such as pacemakers and implantable cardioverter-defibrillators can cause problems for some individuals (Wisconsin Public Service Commission 2004).

EPA reviewers should ensure that air emissions, direct radiation, and liquid releases have all been quantified. Key information should be provided in an appendix, if appropriate. Figure 6-1 depicts the pathways within each of these categories that should be considered in the analysis.

Figure 6-1. Potential Exposure Pathways



Source: NRC 2000.

6.5.1 Air Emissions

Radiological air emission sources differ slightly for boiling water reactors and pressurized water reactors but, in general, nuclear reactors have three primary sources of gaseous radioactive emissions:

- discharges from the gaseous waste management system;
- discharges associated with the exhaust of noncondensable gases at the main condenser if a primary-to-secondary system leak exists; and
- radioactive gaseous discharges from the building ventilation exhaust, including the reactor building, reactor auxiliary building, and fuel-handling building [NRC 1996, Section 2.2.4.1].

These air emissions should be quantified in the EIS.

6.5.2 Direct Radiation

An NPP will emit a measurable amount of direct radiation. The dose an individual or population receives is a function of the amount of radiation emitted by the source, shielding, the distance from the source, and the duration of exposure.

Potential sources of direct radiation include onsite waste facilities, onsite independent spent fuel storage installations, and radionuclides within the reactors and its related structures. The site-specific design of the facility and its components determine the shielding offered. The distance from direct radiation source(s) to members of the public will be specific to the proposed location, and should be specified in the analysis. Standard assumptions are generally made regarding the duration of exposure, generally assuming that an individual is continuously present at that location.

The EIS analysis should summarize the details listed above, including specific information on sources, distances to the maximally exposed individual and to other receptors, and the radiation doses estimated as a result. In each of the four ESP EISs prepared to date (Grand Gulf, Clinton, North Anna, Vogtle), NRC asserted that the applicant had demonstrated that direct radiation doses would be negligible. If this is the case in an ESP or COL EIS under review, the EPA reviewer should ensure that the EIS provides reference to the applicant‘s analysis where details supporting this conclusion can be found.

6.5.3 Liquid Releases

Radiological emissions to waste water are similar in boiling water reactors and pressurized water reactors. In general, radionuclide contaminants in the primary coolant are the source of liquid radioactive waste in reactors. Sources and general categorization of liquid wastes from light water reactor operation may be described as follows (NRC 1996, Section 2.2.4.2):

- clean wastes (“primary coolant, liquid wastes collected from equipment leaks and drains, certain valve and pump seal leaks not collected in the reactor coolant drain tank, and other aerated leakage sources” (NRC 1996, Section 2.2.4.2));

- dirty wastes (“liquid wastes collected in the containment building sump, auxiliary building sumps and drains, laboratory drains, sample station drains, and other miscellaneous floor drains” (NRC 1996, Section 2.2.4.2));
- detergent wastes (laundry wastes and personnel and equipment decontamination wastes with low radioactivity content);
- turbine building floor-drain water (liquid wastes with high conductivity and low radionuclide content); and
- steam generator blowdown (pressurized water reactors only).

The EIS should describe the sources of and amounts of liquid radioactive wastes expected from the proposed NPP.

Tritium Releases

Tritium is a mildly radioactive isotope of hydrogen that occurs both naturally and during the operation of nuclear power plants. Most of the tritium produced in a reactor is as a byproduct of the absorption of neutrons by boron; since it is a good absorber of neutrons, boron is added directly to the coolant water or is used in the control rods to control the fission chain reaction. Lesser amounts of tritium can be produced from the fission process itself, or when neutrons are absorbed by other chemicals in the coolant water (NRC 2006d).

Like normal hydrogen, tritium can bond with oxygen to form water. When this happens, the resulting “tritiated water” is radioactive. Tritiated water (not to be confused with heavy water) is chemically identical to normal water and the tritium cannot be filtered out of the water (NRC 2006d). NPPs routinely release diluted tritiated water under controlled, monitored conditions that the NRC mandates to protect public health and safety.

> Recent events at several nuclear power plants have highlighted a concern with tritium contamination of groundwater as a result of unplanned releases, such as those due to equipment degradation. Subsequent water sampling in and around these plants identified tritium as the primary source of contamination. See information on such releases in Appendix E, which contains a review of known environmental contamination that has occurred at previous nuclear power plants.

6.5.4 Exposure Pathways

In general, the impacts of radiological emissions are evaluated through assessing sources, pathways, and predicted doses to people and organisms. Persons may be exposed to radiation originating in a nuclear power reactor through atmospheric and aquatic pathways (see Figure 6-1). Radioactive fission products (noble gases and some of the more volatile materials like tritium, isotopes of iodine, and cesium) and activation products are released to the air under controlled conditions. Radioactive materials in the liquid effluents are processed in radioactive waste treatment systems. Radionuclides released to surface water include tritium, isotopes of cobalt, and cesium. In both cases, careful monitoring ensures compliance with permitted release limits (NRC 1996, Section 2.3.7.2).

Major exposure pathways include:

- inhalation of contaminated air,
- drinking milk or eating meat from animals that graze on open pasture on which radioactive contamination may be deposited,
- eating vegetables grown near the site, and
- drinking (untreated) water or eating fish caught near the point of discharge of liquid effluents [NRC 1996, Section 2.3.7.2].

Other possible exposure pathways include external irradiation from surface deposition; consumption of animals that drink irrigation water that may contain liquid effluents; consumption of crops grown near the site using irrigation water that may contain liquid effluents; shoreline, boating, and swimming activities; and direct off-site irradiation from radiation coming from the plant (NRC 1996, Section 2.3.7.2).

When an individual is exposed through one of these pathways, the dose is determined in part by the exposure time, and in part by the amount of time that the radioactivity inhaled or ingested is retained in the individual's body.

The EIS should adequately describe the potential exposure pathways to support the estimates of radiation doses to members of the public (see next subsection). Receptor locations should be identified, including schools, hospitals, and residences, and any locations at which plants or animals that become food for the public may be exposed to either direct radiation or contamination.

6.5.5 Criteria for Evaluating Risks from Doses to Members of the Public

Two different types of predicted radiation doses are estimated for members of the public in risk assessments to support the NPP licensing process. The dose to the maximally exposed individual is the dose to the real or hypothetical offsite person potentially subject to maximum exposure from direct radiation, air emissions, and liquid effluents. Average individual doses are also estimated and then, from these, average population doses are predicted for air emissions and liquid effluents. Doses are calculated using site-specific data where available. For those cases in which site-specific data are not readily available, conservative assumptions are used to estimate doses to the public. Dose calculation models such as GALE, LADTAP II (for liquid effluents), and GASPAR II (for gaseous emissions) may be used. EPA reviewers may wish to review these models to gain more familiarity with the inputs and algorithms used to estimate radiological doses from NPP gaseous and liquid effluents.[6]

The risk criteria to which estimated doses are compared are the radiation protection limits established by NRC and EPA to protect human health. In Appendix I to 10 CFR 50, NRC requires NPPs to keep radiation doses from gas and liquid effluents as low as reasonably achievable (ALARA) to individuals located offsite. For liquid effluent releases, the ALARA

[6] These models are available through Oak Ridge National Laboratory's Radiation Safety Information Computational Center (http://rsicc.ornl.gov/rsiccnew/CFDOCS/qryPackage.cfm). Users who wish to request copies of the codes must register on the site and order copies; a per-package fee applies (currently $600 for federal agencies other than the NRC or DOE offices that fund the center).

annual offsite dose objective is 3 millirems (mrem) to the whole body and 10 mrem to any organ of a maximally exposed individual who lives in close proximity to the plant boundary. This ALARA objective is 3% of NRC‘s standard for annual effective dose equivalent of 100 mrem (NRC 2006d).

EPA has promulgated a stricter standard than NRC for public exposure to radiation. EPA‘s standard for annual public exposure from any part of the uranium fuel cycle, including NPP operation, is 25 mrem to the whole body, 75 mrem to the thyroid, and 25 mrem to any other organ of an individual member of the public (41 CFR 190.10(a)). These limits were derived using the ―critical organ” methodology. EPA (1997) compared the ―25/75/25” standard to the dose that would result using the more current ―effective dose equivalent” methodology and concluded that the existing standard would result in an effective dose equivalent of approximately 10 mrem per year, and is therefore generally consistent with existing standards for activities such as CERCLA remediation levels for radiologically contaminated sites (which are generally bounded by an effective dose equivalent of 15 mrem/year).

NRC subsequently incorporated EPA‘s 40 CFR 190 standard (the 25/75/25 standard) into its own regulations (10 CFR 20.1301(e)), and all NPPs must now meet these requirements.

The International Commission on Radiation Protection has set a dose limit of 100 mrem per year as a lifetime annual dose that would pose only a very small health risk and is similar to the dose received from background radiation.

The characterization of impacts on health from radiological exposures should be consistent with these and any other relevant standards and criteria.

6.5.6 Impacts to Wildlife and Plants

An EIS should evaluate the impacts of radioactive effluents on terrestrial plants and animals, and on aquatic organisms (NRC 2000, Section 5.4.4). Terrestrial and aquatic wildlife may be exposed at levels similar to or higher than members of the public, depending on the pathway and the radiation source. Although guidelines have not been established for acceptable levels of radiation exposure to species other than humans, NRC has generally assumed that the limits established for humans would be protective for other species. Scientific consensus data to date indicate that no wildlife and plant species are expected to be significantly more sensitive to radiation than humans (NRC 2000, Section 5.4.4).

6.6 Waste

Consistent with the organization of recent EISs and NRC guidance (NRC 2000, Section 5.5), this section addresses nonradioactive waste system impacts and mixed waste impacts.

Radioactive waste management is covered in various parts of an NPP EIS: (1) radioactive waste management systems are described in the PPE, (2) mixed waste impacts are discussed under operational impacts, (3) radioactive waste impacts are considered in the fuel cycle, (4) transportation of radioactive materials is addressed under transportation, and (5) radioactive waste is also discussed as an impact of decommissioning.

6.6.1 Nonradioactive Wastes

In general, ~~"n~~nonradioactive wastes from NPPs include boiler blowdown,[7] water treatment wastes (sludges and high saline streams whose residues are disposed as solid waste and biocides), boiler metal-cleaning wastes (derived from the chemical additives that remove scale and other byproducts of combustion), floor and yard drains, and stormwater runoff" (NRC 1996, Section 2.2.5).

6.6.1.1 Effluents Containing Chemicals or Biocides

The principal chemical and biocide wastes include the following constituents (IAEA 2007, Section 2; NRC 1996, Section 2.2.5):

- Boric acid and lithium hydroxide. The most common toxic material in evaporator concentrates is boric acid. Boric acid is used to control reactor power and lithium hydroxide is used to control pH in the coolant. These chemicals could be inadvertently released because of pipe or steam generator leakage.
- Sulfuric acid, which is added to the circulating water system to control scale.
- Hydrazine, which is used for corrosion control and is released in steam generator blowdown.
- Sodium hydroxide and sulfuric acid, which are used to regenerate resins. These are discharged after neutralization.
- Spent ion exchange resins used for purification of process water; The ion exchange resins are likely to include toxic and non-toxic metals such as iron, copper, zinc, manganese, or boron.
- Phosphate in cleaning solutions.
- Biocides used for condenser defouling. The power plant cooling tower water generally contains chromium or other chemical anti-fouling materials. Therefore, cooling water blowdown or associated filtrate sludge will also contain these chemicals.
- Sludge (mainly low toxicity mineral-based material but some may contain chromium, copper, or nickel residues as well) and fine particulates from aqueous precipitation and filtration of liquid radioactive waste (IAEA 2007, Section 2.2.1.5).
- Miscellaneous dry solid wastes from maintenance and repair operations include discarded equipment, organic solvents used for degreasing and cleaning, and organic complexing agents from decontamination activities. In addition to the organic compounds, the waste from NPPs may contain lead, mercury, and barium.
- Small wastewater volumes from other design-specific plant systems (NRC 1996, Section 2.2.5).

Overall, organic solvent concentrations from routine NPP operation are not high, ranging from about 50 to 500 ppm. However, other solvents and organic contaminants may be present in

[7] This waste stream results from continual or periodic purging of the impurities that become concentrated in steam boiler systems. Pollutants include metals such as copper, iron, nickel, and chemicals added to prevent scaling and corrosion of steam generator components (Pace University 2000).

measurable quantities in waste arising from non-routine NPP operations (such as chemical cleaning of the secondary side of steam generators). Abnormal events at NPPs can potentially result in appreciable volumes of radioactive waste with chemically hazardous constituents. Abnormal events can include events such as unplanned major modifications, process upsets, and accidents of various kinds. The waste arising from abnormal events may include large quantities of miscellaneous refuse contaminated with decontamination chemicals, process chemicals and cleaning solvents, and adsorbents for organic liquids (such as contaminated pump oils and hydraulic fluids) (IAEA 2007, Section 2.2).

Releases of chemical constituents can affect surface water quality and aquatic ecology. Groundwater contamination and atmospheric deposition are also potentially impacted by chemical constituents. Chlorine and its combination products have toxic effects on aquatic biota, though many power plants have eliminated the use of chlorine or reduced the amount used. Minor chemical spills or temporary off-specification discharges from sanitary waste treatment systems and other low-volume effluents (for example, excessive coliform counts or total suspended solids levels, pH outside of permitted range) may affect aquatic biota. Heavy metals (such as copper, zinc, chromium) may be leached from condenser tubing and other heat exchangers and discharged by power plants as small-volume waste streams or corrosion products and excessive concentrations of heavy metals can be toxic to aquatic organisms. An unknown quantity of water leaks from the bottom of cooling ponds, and may contaminate groundwater due to its elevated salt and metal content. Atmospheric deposition of sulfate from cooling towers was found to have damaged vegetation in the proximity of one power plant (NRC 1996, Section 4.2.1 and 4.3.5.1.2).

The EIS should thoroughly characterize the plant‘s chemical discharges, including effluent treatment facilities and their operating cycles for various modes of normal plant operation; concentrations of each chemical in effluent including average, maximum, and seasonal variations; system- and waste stream-specific chemical use and discharge concentration data; seasonal concentration factors for an evaporative cooling system; natural materials in effluents (average and maximum concentrations (Chapter 3.6.1.I of NRC 2000). An EIS may refer to the applicant‘s environmental report for this information. In some cases, the EIS may state that the design of the various water systems has not been specified and therefore water treatment requirements and water system effluents will not be known. The EIS (or environmental report, if referenced) should provide bounding estimates of liquid nonradioactive waste effluents if the PPE approach is used. The chemical concentrations within effluent streams from a new facility could be controlled through engineering, operational, and administrative controls; however, these may not be known at the time the EIS is completed.

6.6.1.2 Sanitary System Effluents

The EIS should describe any other nonradioactive solid or liquid waste materials such as sanitary and chemical laboratory wastes, laundry solutions, and decontamination solutions that may be created during station operation. The description should include estimates of the quantities of wastes to be disposed, their pollutant concentrations, biochemical oxygen demands at points of release as appropriate to the system, and other relevant data. The manner in which they will be treated and controlled and the procedures for disposal should also be described. Sanitary system designs may not be determined at the time the EIS is completed, but normal and maximum discharge rates could be estimated base on the PPE.

6.6.1.3 Other Waste

Dry solid waste from NPP operations includes cellulose materials (such as paper, rags, clothing and wood), rubber gloves and boots, plastic, steel, and building debris. Such waste would not usually be regarded as hazardous; however, it may contain trace amounts of toxic elements (IAEA 2007, Section 2.2.2).

Shielding materials, such as lead blankets and bricks, may become radiologically or chemically contaminated. The lead itself can be separated for treatment, recycling, or disposal (IAEA 2007, Section 2.2.2).

6.6.2 Mixed Waste

Mixed waste contains both hazardous waste and source, special nuclear, or byproduct material as defined in the Atomic Energy Act of 1954 (42 USC 2011 et seq.). Although NPPs, on average, generate less than 10% of total U.S. mixed waste volumes, the management of this waste is problematic because of a lack of sufficient waste treatment and disposal capacity for specific types of mixed wastes. Environmentally sound management of mixed-waste is a significant challenge for all commercial mixed-waste generators, including NPP operators.

> Mixed waste is generated during routine maintenance activities, refueling outages, health physics activities, and radiochemical laboratory activities. The vast majority of mixed waste that is stored at NPPs is chlorinated fluorocarbons and waste oil. Other sources include liquid scintillation fluids, other types of organic materials, and metals, including lead and chromium and aqueous corrosives (NRC 1996, Section 6.4.5).

The NPP EIS should describe plant systems producing mixed waste, mixed waste storage plans, mixed waste disposal plans or capabilities, and an assessment of both radiological and nonradiological mixed waste impacts. Adverse impacts to ecosystems, offsite populations, or workers from radiological and nonradiological exposures resulting from onsite storage of the mixed waste should be described. Mixed waste may pose additional occupational exposure risk at a NPP site because these waste types are commonly tested and stored on site (NRC 2000, Section 5.5.2).

6.7 Socioeconomic Impacts

This section addresses physical impacts such as noise and odors, socioeconomic impacts, and environmental justice. NRC's environmental standard review plan for preparing EISs directs NRC staff to evaluate environmental justice impacts under the larger category of socioeconomic impacts.

As previously stated, the Environmental Description (Affected Environment) chapter of the EIS should describe the population distribution and community characteristics within the region that are likely to be affected by the proposed action and each alternative. The EIS should include descriptions of relevant past, current, and projected population distributions. Both permanent and transient populations should be identified, as well as minority and low-income populations. Demographics (transient and migrant labor) and community characteristics (economy, transportation, property taxes, aesthetics and recreation, housing, public services, education) should be summarized. This baseline description should then be used to assess impacts on social, economic, and community resources (and would also form the basis for population-level radiological exposure estimates).

6.7.1 Physical Impacts

6.7.1.1 Noise

"The principal sources of noise from plant operations are natural draft and mechanical draft cooling towers, transformers, and loudspeakers. Other occasional noise sources may include auxiliary equipment such as pumps to supply cooling water from a remote reservoir. Generally, these noise sources are not perceived by a large number of people off-site" (NRC 1996, Section 4.3.7). Therefore, noise issues are not generally a source of significant environmental impacts for new NPPs, although NRC (2000) calls for evaluation of this issue in the EIS.

6.7.1.2 Aesthetics

Nuclear power plants, particularly those with natural draft cooling towers, stand out from their background. NPPs are clearly visible and recognizable from a distance (NRC 1996, Section 4.7.6.1). Nuclear plants are usually situated in open areas near bodies of water, rendering cooling towers even more visible. Although they are visible from as far away as 10 miles, the structures are typically partially obscured by trees, buildings, or even slight changes in topography. There are few environments where such structures are perceived as well-integrated with surrounding landscapes.

In addition to the physical presence of the plant, vapor plumes from heat dissipation systems may have aesthetic impacts due to the increased moisture and chemical content of the air. Because warm, moist air would be emitted to the atmosphere from the wet cooling towers, elevated plumes would at times extend above the cooling towers and be visible off site (NRC 1996, Section 4.7.6). Additionally, the visible vapor plumes associated with cooling towers can rise more than 5,000 feet above the towers and extend as far as 9 miles downwind. Such a presence, although visible only part of the time under certain meteorological and seasonal conditions, extends the plant-related viewshed considerably beyond that of a tower alone.

The presence of transmission lines may also require consideration in an evaluation of cumulative impacts on visual resources.

6.7.1.3 Cumulative Impacts Related to Transmission Lines

Transmission lines can degrade aesthetic resources by intruding on a view of a landscape. Transmission lines can also affect residential property values, and the value of agricultural land in cases where poles interfere with operation of farm equipment.

Transmission lines do not usually interfere with normal television and radio reception. In some cases, interference is possible at a location close to the right-of-way due to weak broadcast signals or poor receiving equipment (Wisconsin Public Service Commission 2004).

6.7.2 Social and Economic Impacts

An influx of NPP workers and their families can cause significant changes in local housing, schools, community, and social services. The level of impact will depend on how many individuals in-migrate relative to the existing population levels. In general, one would expect that social and community infrastructure had developed during the construction phase, to accommodate the larger construction workforce, such that impacts from smaller influx of operational workers (and their families) would be expected to be less on existing infrastructure/services and mostly beneficial in terms of economic impacts.

> Social and economic impacts will vary depending on how rural the surrounding area is and where the majority of the workforce chooses to live. For example, if the in-migrating workforce is evenly distributed throughout the host county/adjacent counties and there are large towns close by to accommodate the influx, then the regional impacts would be expected to be low. But if the area is mostly rural with very few towns nearby (and those are very small), and the majority of workers choose to live there, then the local impacts can be larger and adverse (NRC 2000). Both types of impacts need to be addressed.

The following social and economic impacts were identified in the NRC's Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437 (NRC 1996, Section 4.7), and are discussed below as they would apply to a new NPP. For all of these areas both impacts to the region and to the local community should be addressed.

6.7.2.1 Housing

The number of operations workers required will be small relative to original construction work force size, and the operations workers are generally introduced gradually to the site so that housing demand will also increased gradually. The number of workers will increase during plant outages for re-fueling or maintenance.

A new NPP will have a continuing impact on housing value and marketability. Housing choices of local residents are rarely affected by the presence of the plant. However, buyers from outside the community may be averse to purchasing properties close to an NPP. The impact on housing value and marketability will probably depend upon whether a new plant is located at an existing plant site, a brownfield site, or a greenfield site.

6.7.2.2 Taxes

Direct and indirect tax payments to local jurisdictions are judged to be a beneficial effect of operating the NPP in a community.

6.7.2.3 Public Services

The following public services can be influenced by plant operation:

- Education: Children of the plant staff must be assimilated the into local school systems.

- Transportation: Impacts of operational staff commuting to and from work and conducting local non-work related trips are site-specific and are determined primarily by the local transportation infrastructure, including public transportation and existing road conditions. Traffic/increased congestion from commuters to the plant should be assessed. Related traffic safety issues can include impacts from fogging and icing (from cooling tower operation) and increased traffic from the operations workforce.

- Public safety: The EIS should determine if there will be a need for additional police or fire personnel as a result of operation.

- Social services: An increase in available services may be required to meet the needs of operational workers and families.

- Public utilities: An increased problem with water availability may occur in conjunction with plant demand and plant-related population growth as a result of current water shortages in some areas of the country. These shortages may result in moderate impacts to public water supplies at sites with limited water availability.

- Tourism and recreation: Taxes paid by the plants have allowed some municipalities to improve their recreational facilities and programs. Some plants have also increased local tourism.

In general, impacts are small if the existing infrastructure (facilities, programs, and staff) can accommodate any plant-related demand without a noticeable effect on the level of service. Moderate impacts arise when the demand for service or use of the infrastructure is sizeable and would noticeably decrease the level of service or require additional resources to maintain the level of service. Large impacts would result when new programs, upgraded or new facilities, or substantial additional staff are required because of plant-related demand.

6.7.2.4 Economic Structure

The economic structure of communities can be changed, depending on the percentage of total employment that is plant-related.

6.7.3 Environmental Justice

For background on environmental justice considerations, the reviewer is referred to Section 5.6.3, in which environmental justice issues related to construction are discussed.

In the Environmental Description (Affected Environment) chapter, the EIS should have explained existing demographic data, surveys that have been performed, and uncertainties that exist. Data on low-income populations, minority populations, and children, especially if any of these subgroups may be disproportionately affected by the proposed action or alternatives, should have been included. When minority or low-income populations are identified in a potentially significant environmental impact area, NRC specifies considerations for determining the potential for “disproportionately high and adverse effects.” These are listed in Section 5.6.3 of this guidance document.

In general, the economic impacts from operation would be expected to be beneficial to all members of a community, including minority and low-income populations, due to more jobs, increased corporate taxes to be used for improvements to social services, schools, hospitals, and other services. However, a possible adverse effect to environmental justice from area economic improvements is that the increases in corporate taxes and revenues, such as those relating to the housing market, may cause housing prices or taxes to go up, making it more difficult for low income populations to pay their current property taxes (if they are homeowners) or to afford new housing (if they try to buy a home). Also, minority and low-income populations may not necessarily benefit from an increase in jobs if they do not have the necessary education or skills to work at a nuclear plant.

If the EIS indicates no adverse health and safety impacts to the public from normal operation, then there should be no related environmental justice concerns. However, the EIS should discuss the potential for health and safety-related impacts in the case of a non-routine release or accident in terms of the demographics of the population in the EPZ. For example, contaminated food or water from various radiological pathways could disproportionally affect a certain portion of a population found to be more dependent on area fisheries or who grow their own crops (subsistence farming or fishing). All of these should be examined in the EIS as appropriate and relevant. The EIS should also make sure that the characteristics and requirements of the local population are properly accounted for and factored into evacuation and emergency response plans. Socioeconomic impacts associated with the emergency measures themselves should be discussed.

6.8 Accidents

In accordance with NRC guidance, NPP EISs evaluate design basis accidents, severe accidents, and transportation accidents, and should summarize severe accident mitigation alternatives. A *design basis accident* is one that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to assure public health and safety. A *severe accident* is one that may challenge safety systems at a level much higher than expected. Transportation accidents are discussed in Section 7 of this guidance document.

Proximity to heavily populated areas will be an important consideration if an accident were to occur, in terms of population-level risk, potential pathways for exposure, and emergency planning and evacuation considerations.

Since accidental radiological releases (whether small or large, ongoing or sudden) are neither planned nor permitted, they would be considered to have an adverse impact regardless of the magnitude of the resulting radiological exposure, and should be characterized as such in the EIS. That is, the EIS should not dismiss the impacts of accidental releases that may be described as small or minor, since radiological exposures are cumulative.

6.8.1 Design Basis Accidents

As either part of their environmental report or safety analysis report, the applicant will have identified the design basis accidents that may result in environmental releases, and will have estimated risks to the public posed by each of those accidents (NRC 2000, Section 7.1). The ESP or COL EIS will summarize this information, supplementing it as required to fully describe the human health risks that would associated with design basis accidents.

For a COL, OL, or CP EIS, the safety analysis report or environmental report should have analyzed, and the EIS should summarize, six aspects of the radiological consequences of potential design basis accidents:

1. selected bounding design-basis accidents,
2. accident source terms,
3. the major structures, systems, and components of the facility that are intended to mitigate the radiological consequences of a design-basis accident,
4. the characteristics of fission product releases from the proposed site to the environment,
5. the meteorological characteristics of the proposed site, and
6. the total calculated radiological consequence dose at the exclusion area boundary, low population zone, and control room from the bounding design-basis accidents [NRC 2007b, Section 15.0.3].

If the COL EIS proposes use of a certified design or references an ESP EIS for the proposed NPP, relevant parts of the previous analyses may be incorporated and summarized.

For an ESP EIS, the approach taken to assessing design-basis accidents can vary, as follows (NRC 2007b, Section 15.0.3):

- If the ESP references a certified reactor design, the EIS may reference and summarize the radiological consequence evaluation conducted for design certification, which include analysis of a postulated set of short-term atmospheric relative concentrations at the exclusion area boundary and low population zone in lieu of site-specific meteorological and site layout/vicinity data. If this approach is taken, the EIS should demonstrate that parameters of the proposed site fall within those postulated in the design certification.

- If the ESP EIS uses the PPE approach, the PPE values and associated information provided by the applicant in the ESP application would contain information addressing the very detailed radiological consequence evaluation factors listed in 10 CFR 50.34(a)(1). The conclusions of this analysis should be summarized in the EIS.

- If an ESP application and the corresponding EIS do not reference a certified design or use a PPE approach, the same information provided for a COL EIS (with the exception of doses in the control room) is required from the applicant, and should be summarized in the ESP EIS.

6.8.2 Severe Accidents

Severe accidents are those involving multiple failures of equipment or function. Therefore, their likelihood of occurrence is lower but their consequences would be higher. Examples of severe accidents that may be evaluated, some of which are only relevant for particular designs, include the following (NRC 2006a, 2006b, 2006c, Section 5.10.2 in each):

- No loss of containment.
- Transients[8] followed by failure of high-pressure coolant makeup water and failure to depressurize in a timely fashion.
- Short-term station blackout with reactor core isolation cooling (RCIC) failure and onsite power recovery in eight hours.
- Station blackout with RCIC available for about eight hours.
- Station blackout (more than eight hours) with RCIC failure.
- Transients followed by failure of high-pressure coolant makeup water, successful depressurization of reactor, failure of low-pressure coolant makeup water.
- Transient, loss-of-coolant accident (LOCA), and anticipated transient without scram[9] (ATWS) events with successful coolant makeup water, but potential prior failure of containment.
- Small/medium LOCA followed by failure of high-pressure coolant makeup water and failure to depressurize.
- LOCA followed by failure of high pressure coolant makeup water [NRC 2006c, Table 5-13].
- ATWS followed by boron injection failure and successful high-pressure coolant makeup water.

Severe accident risks are evaluated for exposures occurring through the atmospheric pathway, the surface water pathway, and the groundwater pathway. Unlike the potential exposures to individuals that are estimated as a result of the analysis of design-basis accidents, the

[8] A transient is a change in the reactor coolant system temperature and/or pressure due to a change in power output of the reactor. Transients can be caused (1) by adding or removing neutron poisons, (2) by increasing or decreasing electrical load on the turbine generator, or (3) by accident conditions (NRC 2007c).

[9] A scram is the sudden shutting down of a nuclear reactor, usually by rapid insertion of control rods, either automatically or manually by the reactor operator. May also be called a reactor trip (NRC 2007c).

consequences of severe accidents are characterized in terms of exposures to population groups (NRC 2007a, Section 7.2).

The risks for specific accident types are defined as the product of the probability of that type of accident occurring multiplied by the estimated consequences for that type of accident. As with the evaluation of design-basis accidents, detailed quantitative documentation of the basis of probabilistic estimates of releases do not need to be laid out in the EIS, but can be referenced to details in FSARs and safety evaluation reports.

The EIS will also present a summary of the severe accident mitigation alternatives that review and evaluate plant-design alternatives that could significantly reduce a severe accident‘s risk by preventing substantial core damage or limiting releases from containment (NRC 2007a, Section 7.3). NRC reviews emergency planning details for accidents as part of the safety review process, and this topic is not generally addressed in an NPP EIS.

NRC (2007a, Section 7.3) stated the following:

> A 1989 court decision (*Limerick Ecology Action vs. NRC*, 869 F.2d 719 [3rd Cir.]), referring to NRC policies, stated that the ―Action of NRC in addressing severe accident mitigation design alternatives through policy statement, not rule making, did not satisfy NEPA, where policy statement did not represent requisite careful consideration of environmental consequences, excluded consideration of design alternatives without making any conclusions about effectiveness of any particular alternative, and issues were not generic in that impact of severe accident mitigation design alternatives on environment would differ with particular plant‘s design, construction and locations."

Therefore, NRC now considers the evaluation of severe accident mitigation alternatives in all NPP EISs (and also in conjunction with the design certification process) to ensure that plant design changes with the potential for improving severe accident performance are identified and evaluated (NRC 2007a, Section 7.3).

Under a proposed rule (72 Federal Register 191:56287-56308, October 3, 2007), NRC would require reactor designs to be assessed for the effects of the impact of a large, commercial aircraft on the nuclear power plant. The objective of this rule is to require nuclear power plant designers to perform a rigorous assessment of design features that could provide additional inherent protection to avoid or mitigate, to the extent practicable, the effects of an aircraft impact, with reduced reliance on operator actions. If implemented, this rule may generate information that is also summarized or referenced within an EIS proposing an NPP of a particular design. NRC‘s guidance for new NPP EISs (NRC 2000, 2007a) does not currently address this topic.

6.8.3 Consideration of Potential Impacts of a Terrorist Act

Protecting NPPs from land-based assaults, deliberate aircraft crashes, and other terrorist acts has been a heightened national priority since the attacks of September 11, 2001, and the NRC has strengthened its regulations on nuclear reactor security. Several provisions to increase nuclear reactor security are included in the Energy Policy Act of 2005 (CRS 2006).

As of the date this guidance document was finalized, whether NPP EISs must consider the impacts of terrorist acts depends on the location of the proposed plant. The Ninth Circuit Court of Appeals concluded in *San Luis Obispo Mothers for Peace v. Nuclear Regulatory Commission* that it “was unreasonable for the NRC to categorically dismiss the possibility of terrorist attack on the Storage Installation and on the entire Diablo Canyon facility as too “remote and highly speculative” to warrant consideration under NEPA” (449 F.3d 1016, 1030 (9th Cir. 2006)). The U.S. Supreme Court declined to hear an appeal of the decision. Subsequently, in a proceeding on the license renewal for the Oyster Creek, New Jersey, Nuclear Generating Station, the NRC held that NEPA did not require “the NRC to consider the environmental consequences of hypothetical terrorist attacks on NRC-licensed facilities” (NRC 2007e). In explaining how this decision related to the *San Luis Obispo Mothers for Peace* decision, the NRC noted that “an agency is not required to acquiesce in an unfavorable decision when faced with the same legal issue in another circuit” (NRC 2007e). Thus, when reviewing NRC EISs, EPA reviewers should note that the Ninth Circuit decision in *San Luis Mothers for Peace* applies only to EISs prepared for facilities located within the Ninth Circuit.[10]

Therefore, with the exception of sites within the Ninth Circuit‘s jurisdiction, NRC has directed that terrorist attacks do not need to be included as an assessment parameter. An NRC memorandum and order regarding the EIS for the Grand Gulf ESP states that NEPA “does not require the NRC to consider the environmental consequences of hypothetical terrorist attacks on NRC-licensed facilities” (NRC 2007d). This memorandum is consistent with another NRC memorandum regarding consideration of terrorist attacks in environmental impact analysis for NPP license renewal (NRC 2007e). In addition, in response to public comments received during the scoping process for the North Anna ESP EIS, the NRC states that they “determined that terrorism is not predictable and is not an inevitable consequence of a proposed licensing action, and that an EIS is not an appropriate format to address the challenges of terrorism” (NRC 2006a).

In conclusion, terrorist attacks on NPPs that result in catastrophic releases of nuclear material are not considered reasonably foreseeable circumstances under NEPA. Accordingly, they do not need to be evaluated except within the jurisdiction of the 9th Circuit Court of Appeals, as appropriate, in an EIS for a license to operation an NPP. Nevertheless, as part of the NPP licensing process, an applicant must ensure that the approved NPP will be designed to ensure the chance of a catastrophic release is very remote. Accordingly, it would be appropriate for an NPP EIS to discuss the preventive measures that will be employed at the NPP.

[10] The Ninth Circuit‘s jurisdiction covers Alaska, Arizona, California, Guam (U.S. territory), Hawaii, Idaho, Montana, Nevada, the Northern Mariana Islands (U.S. commonwealth), Oregon, and Washington.

Section 6 References

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

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NRC 1996: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2004: U.S. Nuclear Regulatory Commission. Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues, LIC-203. Office of Nuclear Reactor Regulation. May 24, 2004. http://www.nrc.gov/reactors/operating/licensing/renewal/introduction/introduction-files/lic-203rev1.pdf

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7. Transportation of Radioactive Materials

- Has transportation of radioactive materials been evaluated, including potential accidents during shipping?

This section addresses both the radiological and nonradiological environmental impacts from normal operating and accident conditions associated with shipping radioactive materials and radioactive waste. This section also explains the generic treatment of transportation impacts in an NPP EIS and major areas of impact resulting from transportation.

The information presented is largely based on findings from NRC's NUREG 1437 –Generic Environmental Impact Statement for License Renewal of Nuclear Plants" (NRC 1996, Section 6.3), which addresses the impacts of transportation to and from a light water reactor (BWRs and PWRs). The effects of transportation related to other reactor types may differ slightly, depending on the design type. Note that transportation impacts from the Gas Turbine – Modular Helium Reactor and Pebble Bed Modular Reactor have been considered in the existing ESP EISs (NRC 2006a, NRC 2006b, NRC 2006c, Section 6. 2 in each), which offer the EPA reviewer a comparison of potential impact similarities and differences between design types.

Transportation of radioactive material has been presented as part of a chapter also discussing the nuclear fuel cycle and decommissioning in recent ESP EISs (NRC 2006a, 2006b, 2006c, Section 6.2 in each). Recent COL environmental reports (Dominion 2007, Section 3.8; Entergy Operations Inc. 2008, Section 3.8) address transportation under the topic of plant description, but then refer back to the ESP EIS. NRC's –Generic Environmental Impact Statement for License Renewal of Nuclear Plants," NUREG 1437 (NRC 1996, Section 6.3), also addresses all three types of radioactive material transport under its discussion of the uranium fuel cycle and radioactive waste management.

> There are three types of radioactive material shipments to and from nuclear plants: (1) nuclear fuel shipments from fuel fabrication facilities to plants for loading into reactors (generally occurring on a 12- to 18-month cycle); (2) spent-fuel shipments, currently to other NPPs with available storage space (usually limited to plants owned by the same utility) and potentially to a permanent repository; and (3) radioactive waste shipments including routine and refurbishment-generated low-level waste transported from plants to disposal facilities, and routine low-level waste shipped to off-site facilities for volume reduction.

The reviewer is referred to Section 8 of this guidance on the nuclear fuel cycle for perspective on the various off-site steps that require transportation of radioactive material. While other shipments occur within the entire fuel cycle (for example, enriched uranium hexafluoride shipped to a fuel fabrication facility), only the three types of radioactive material transport mentioned above are analyzed in the transportation section of an NPP EIS. (Note: Section 6 of this guidance, –Operational Impacts", describes the environmental impacts of nonradioactive and mixed waste.)

Overall, potential radiological impacts from transportation include possible exposures of transport workers and the general public along the proposed transportation routes, and radiation exposure to these groups that may occur through accidents along transportation corridors.

Nonradiological impacts include traffic density, weight of the loaded truck or railcar, heat from the fuel cask, and transportation accidents (NRC 1996, Section 6.3).

EPA §309 EIS reviewers should consider the following points.

1. **Environmental impact data exist for light water reactors meeting specific criteria, including transportation of fuel and waste to and from light water reactors, but not other reactor types.** These data are presented in 10 CFR 51.52 in Table S–4, ―Environmental Impact of Transportation of Fuel and Waste To and From One Light-Water-Cooled Nuclear Power Reactor .” For reactors not meeting the conditions listed in 10 CFR 51.52 (a) for which the Table S-4 data are relevant, the EIS must present a full description and detailed analysis of the environmental effects of transportation of fuel and wastes to and from the reactor, including values for the environmental impact under normal conditions of transport and for the environmental risk from accidents in transport.

2. **Changes in the nuclear fuel cycle should be considered.** Disposal requirements could change, among other things, for these next generation NPPs; see Section 8 of this guidance document.

3. **Transportation analysis may already exist for plants co-located with existing plants, although potential volumes to be transported would change.** Transportation to and from greenfield sites would require closer scrutiny since the proposed modes and routes will not have been addressed before.

4. **Transportation requirements may result in the need to modify/improve or expand existing highway, rail, barge, and intermodal facilities (if more than one mode is used to reach a given site).** Impacts from these related activities should be addressed in the EIS as well, in terms of both their construction and operation.

Section 7 References

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Dominion 2007: Dominion Energy, Inc. North Anna 3, Combined License Application, Part 3: Applicant's Environmental Report - Combined License Stage. November 2007. ADAMS accession number 081060218.

Entergy Operations, Inc. 2008: Grand Gulf Nuclear Station, Unit 3 COL Application, Part 3, Environmental Report, Revision 0, February 2008. ADAMS accession number 080650101.

NRC 1996: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

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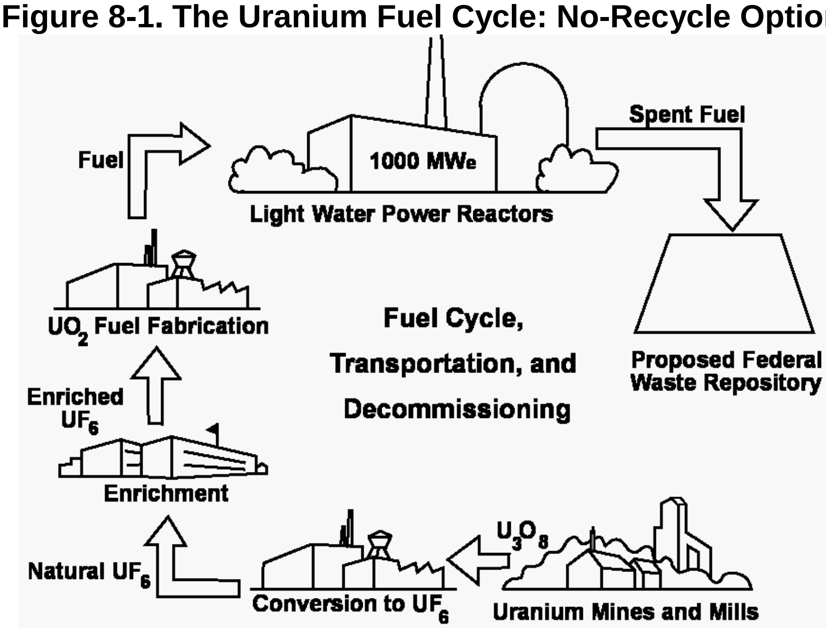
8. Nuclear Fuel Cycle

8. Nuclear Fuel Cycle

- Does the EIS address the environmental impacts of the nuclear fuel cycle attributable to the proposed NPP?
- Are the standard NRC data modified as appropriate to reflect the details of the proposed reactor design when characterizing the environmental effects?
- If other than a light water reactor is proposed, does the EIS present the basis for evaluating the contribution of the environmental effects of fuel cycle activities?
- Have reasonable assumptions been made about the onsite storage of spent fuel?

The nuclear fuel cycle includes the –front end” process of mining uranium, milling, conversion, enrichment, fuel fabrication, and associated transportation of products prior to using the fuel in a nuclear power plant. It also includes the –back end” process of handling, storing, and managing spent fuel for reprocessing or transport to a Federal repository. See Figure 8-1.

Figure 8-1. The Uranium Fuel Cycle: No-Recycle Option



Source: NRC 2006.

Currently, neither a reprocessing facility (which would allow fuel recycling) nor a federal waste repository is approved (licensed) in the United States, and spent fuel is in interim storage. Plans call for high-level radioactive waste (including spent nuclear fuel) to be disposed underground, in a deep geologic repository at Yucca Mountain, NV, with no current provision for reprocessing (NRC 2007a, NRC 2001). However, a DOE program, the Advanced Fuel Cycle Initiative DOE 2008a), includes development of an integrated spent fuel recycling plan that, upon implementation, could provide options for steps within the uranium fuel cycle other than those described here. Fuel cycle steps and associated environmental hazards, based primarily on information from NRC‘s ―Stages of the Fuel Cycle” (NRC 2007a), are described below.

The impacts of nuclear power reactor operation, which is part of the fuel cycle, are discussed in Section 6, ―Operational Impacts.” Transportation of radioactive material, considered part of the fuel cycle, is addressed separately in Section 7, ―Transportation of Radioactive Materials”. The reviewer is also referred to the ―useful tools” in Appendix H for additional background information on the nuclear fuel cycle.

8.1 Stages of the Nuclear Fuel Cycle

8.1.1 Mining

In the past, uranium was mined from open pits and deep shaft mines and sent to a mill for processing. However, in situ leach operations have become more common, in which solutions are injected into the ore deposit that dissolve the uranium into it, which is then pumped out (NRC 2007a).

Mining uranium produces waste materials including excavated top soil, overburden, weakly uranium-enriched waste rock, subgrade ores, and evaporation pond sludges and scales. These wastes typically contain radionuclides of radium, uranium, and thorium, but are not classified as radioactive wastes (EPA 2007a).

8.1.2 Milling

Uranium is extracted from ore at uranium mills and at in-situ leach facilities. Both extraction processes concentrate the uranium into the uranium oxide product known as "yellowcake" (U_3O_8).

At conventional uranium mills, ore arrives via truck, is crushed, and 90 to 95% of the uranium is leached, usually using sulfuric acid (alkaline leaching may also be used). The solid (sandy) waste from the conventional uranium milling process is called mill tailings. Uranium mill tailings contain radium, a source of radon and its progeny which can pose an inhalation cancer risk to workers (NRC 2007a).

In-situ leaching can recover uranium from low-grade ores that may not be economically recoverable by other methods. A leaching agent, such as oxygen with sodium carbonate, is injected through wells into the ore body, where it dissolves the uranium, and then is pumped to the processing plant, where the uranium is separated using ion exchange (NRC 2007a).

Milling operations pose occupational hazards because of the chemicals used in the extraction processes and the chemical toxicity of uranium. Radiological hazards are low, except for radon and radon progeny releases (NRC 2007a).

8.1.3 Conversion to Uranium Hexafluoride

The yellowcake is processed at a conversion facility, where impurities are removed and the uranium is combined with fluorine to produce pure uranium hexafluoride (UF_6) gas. The UF_6 is then pressurized and cooled to bring it to a liquid state, the form in which it is shipped to an enrichment plant (NRC 2007a).

The strong acids and alkalis used in conversion produce very soluble forms of the yellowcake powder, increasing the potential for uranium inhalation by workers. These extremely corrosive chemicals are also potential fire and explosion hazards (NRC 2007a).

8.1.4 Enrichment

Nuclear reactor fuel requires a higher concentration of the U^{235} isotope than exists in natural uranium ore. Normally, the amount of U^{235} is enriched from 0.7% of the uranium mass to about 5%. Gaseous diffusion is the only process currently used in the U.S. to enrich uranium for use as nuclear reactor fuel (NRC 2008). Gaseous diffusion involves heating the solid form of UF_6 that was received by the facility until its gaseous form is reached. In gaseous form, lighter U^{234} and U^{235} atoms are separated from the heavier U^{238} though diffusion barriers. The resulting UF_6 gas enriched with the U^{235} isotope is then condensed into a liquid, then solidified, and is transported to a fuel fabrication facility where it can be manufactured into reactor fuel (NRC 2007a). Gaseous diffusion can pose chemical and radiological hazards such as a potential UF_6 release or a criticality accident from mishandling the enriched uranium (NRC 2007a).

NRC has issued licenses for facilities to enrich uranium in the U.S. via gas centrifuge processing, and two such facilities are currently under construction (NRC 2008). In this process, centrifugal force generated in a rotating cylinder containing UF_6 gas separates the lighter from the heavier uranium isotopes. A series (or ―cascade") of centrifuges repeatedly spins the products of the previous step, resulting in a progressively greater concentration of U^{235} (NRC 2008).

Laser enrichment is another technology that can be used to enrich uranium for use as nuclear fuel, but it is a more difficult process, though more efficient. This technology is still in development, and it may be available in the future in the U.S. (NRC 2008).

8.1.5 Fuel Fabrication into Uranium Oxide

Fuel fabrication facilities convert enriched UF_6 into fuel for nuclear reactors. The uranium can take the form of uranium dioxide powder, which is then pressed into pellets and sintered into a ceramic form for construction into the fuel assemblies for light water reactors (NRC 2007a).

Fuel fabrication also can create mixed oxide (MOX) fuel, in which a mixture of uranium dioxide powder and plutonium oxide powder are manufactured into the fuel. The plutonium used to generate MOX fuel has been recycled from applications in decommissioned nuclear weapons components. Most commercial light water reactors can use MOX fuel.

8.1.6 Interim Storage

Spent nuclear fuel is used fuel from a reactor that is no longer efficient in creating electricity because its fission process has slowed. However, it is still thermally hot and highly radioactive. In the U.S., spent fuel may be stored in spent fuel pools and or placed in dry cask storage. Currently, most spent nuclear fuel is stored in specially designed pools at individual reactor sites around the country. If pool capacity is reached, licensees may move toward use of above-ground dry storage casks (NRC 2007a).

8.1.7 Long-Term Storage

Currently no long-term storage facility exists for spent nuclear fuel. The Nuclear Waste Policy Act of 1982 specified that high-level radioactive waste will be disposed underground in a deep geologic repository at Yucca Mountain, NV (NRC 2007b). An opening date in 2017 is projected, based on a "best-achievable schedule," and is predicated upon enactment of new legislation (DOE 2007).

8.2 Existing NEPA Reviews

Each step in the nuclear fuel cycle described above has been the subject of a comprehensive NRC or DOE NEPA review that assessed its environmental impacts, or is anticipated to be the subject of a future NRC NEPA review(s) (for example, ongoing programmatic EIS and potential follow-on tiered NEPA reviews relating to multiple in situ mining proposals from the western states). Relevant NEPA reviews include, but are not necessarily limited to, those described below:

NRC NEPA Reviews

- Notice of Intent to Prepare Generic EIS for Uranium Milling Facilities: 72 Federal Register 40344 (July 24, 2007). http://a257.g.akamaitech.net/7/257/2422/01jan20071800/edocket.access.gpo.gov/2007/E7-14362.htm

- Generic EIS for In-Situ Leach Uranium Milling Facilities, NUREG 1910: The NRC expects numerous license applications for in-situ leach uranium milling facilities in 2008 through 2010. This generic GEIS addresses common issues associated with environmental reviews of such facilities located in the western United States. The Final Generic EIS is expected in 2009. http://www.nrc.gov/materials/fuel-cycle-fac/licensing/geis.html

- Final EIS on Construction and Operation of Mixed Oxide Fuel Fabrication Facility at Savannah River Site, South Carolina, NUREG 1767, February 2005. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1767/

- Final EIS for the Proposed National Enrichment Facility in Lea County, New Mexico, NUREG 1790, June 2005. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1790/

- Generic EIS for License Renewal of Nuclear Plants, NUREG 1437, 1996. This EIS provides a detailed analysis of the environmental impacts from the uranium fuel cycle (in the executive summary under Uranium Fuel Cycle and Management of Waste, and in Chapter 6.2, ―Impacts of the Uranium Fuel Cycle"), most of which is also applicable to those new NPPs proposing light water reactors. This analysis addressed fuel cycle impacts on land use, water consumption, thermal effluents, chemical effluents, radioactive releases, burial of transuranic and high- and low-level wastes, radiation doses from transportation other than fuel to the plant itself and spent fuel and radioactive wastes from the plant itself, and occupational exposures. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

DOE NEPA Reviews

- Final EIS for a Geological Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada. DOE/EIS-0250 (February 2002). http://www.eh.doe.gov/nepa/eis/eis0250/eis0250index.html

- Final EIS for the Mode of Transportation and Nevada Rail Corridor for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County. DOE/EIS 0250F (April 2004 Record of Decision). (This EIS is not currently available to the public online.)

- Final EIS for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Paducah, Kentucky, Site. DOE/EIS-0359 (June 2004). http://www.eh.doe.gov/nepa/eis/eis0359/index.html

- Final EIS for Construction and Operation of a Depleted Uranium Hexafluoride Conversion Facility at the Portsmouth, Ohio, Site. DOE/EIS-0360 (June 2004). http://www.eh.doe.gov/nepa/eis/eis0360/index.html

8.3 Considerations for EPA Reviewers of NPP EISs

NRC is required to address the environmental impacts of the nuclear fuel cycle as part of an EIS for NPP construction and operation. The process-, program-, and site-specific EISs listed in the previous section illustrate the interconnectedness of the actions and the NEPA compliance foundation for all aspects of the nuclear fuel cycle.

10 CFR 51.51, ―Uranium fuel cycle environmental data–Table S-3," states that environmental data for the fuel cycle can be applied generically in an applicant‘s environmental report (which forms the basis for this analysis in the NPP EIS):

> Under 10 CFR 51.50, every environmental report prepared for the construction permit stage or early site permit stage or combined license stage of a light-water-cooled nuclear power reactor, and submitted on or after September 4, 1979, shall take Table S–3, Table of Uranium Fuel Cycle Environmental Data, as the basis for evaluating the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation of radioactive materials and

> management of low-level wastes and high-level wastes related to uranium fuel cycle activities to the environmental costs of licensing the nuclear power reactor. Table S–3 shall be included in the environmental report and may be supplemented by a discussion of the environmental significance of the data set forth in the table as weighed in the analysis for the proposed facility [10 CFR 51.51].

Data used in NRC's development of Table S-3 are cited as being based on the 1974 document ―Environmental Survey of the Uranium Fuel Cycle," WASH-1248, and its supplements. Table S-3 is available online at http://www.nrc.gov/reading-rm/doc-collections/cfr/part051/part051-0051.html.

The values in Table S-3 do not always apply generically. For example, the fuel cycle impacts are based on a reference 1000-MW(e) light water reactor operating at an annual capacity factor of 80 percent for a net electric output of 800 MW(e). For other than light water reactors, 10 CFR 51.50 requires the applicant to present the basis for evaluating the contribution of the environmental effects of fuel cycle activities for the nuclear power reactor.

Additional considerations for EPA §309 reviewers include the following:

- Environmental impacts for those proposals that include light water reactors will use values directly from Table S-3, or may adapt the values to suit the specific proposed reactor or the PPE if the bounding values are different than the reactor referenced in the table. Specific categories of natural resource use included in Table S-3 relate to land use, water consumption, thermal effluents, chemical effluents, radioactive releases, burial of transuranic and high- and low-level wastes, radiation doses from transportation, and occupational exposures (NRC 1996, Section 6.2).

- Those proposals for reactor types other than light water reactors should include additional information and analysis to identify the differences between their reactor type/impacts and those already evaluated for light water reactors. Nuclear fuel cycle impacts for other reactor types have not been detailed in a comparable manner, precluding this guidance document from defining what the accepted approach will become for addressing them. A lessons learned report on the ESP process noted that additional challenges in the environmental impact process exist when other than light water reactors are considered (DOE 2008b): certain reactor types do not meet the entry conditions for use of the generic treatments in Table S-3 and, according to an ESP applicant, interest in other-than-light-water reactors places additional burdens on the ESP or COL applicants to consider and defend such individual and cumulative impacts within the ESP or COL application.

- A number of fuel management improvements have been adopted by NPPs to achieve higher performance and to reduce fuel and separative work (enrichment) requirements. Since Table S–3 was promulgated, these improvements have reduced the annual fuel requirement. (Section 6.2 of NUREG-1437 discusses the sensitivity to certain changes in the fuel cycle on the environmental impacts in greater detail.)

- Increased import of foreign uranium for U.S. reactors and changes in import restrictions could move impacts of uranium mining and milling abroad. The economic conditions of the uranium market currently favor utilization of foreign uranium at the expense of the domestic uranium industry. These market conditions have led to the closing of most U.S. uranium mines and mills, which have decreased the environmental impacts in the United States from these activities. This also introduces additional uncertainty into the Table S-3 values.

- Other aspects of the conditions and data from which the Table S-3 values were derived are also subject to changes over time. For example, onsite storage of spent fuel may continue longer than expected due to uncertainty regarding ultimate disposal, which led EPA to recently comment on the Vogtle Draft ESP EIS as follows (EPA 2007b):

> In the Waste Confidence Rule (10 CFR 51.23), the Commission generically determined that the spent fuel generated by any reactor can be safely stored on-site for at least 30 years beyond the license operating life of the rector. Ultimately, long-term radioactive waste disposition will require transportation of wastes to a permitted repository site. The DEIS notes that in the high-level waste and spent fuel disposal component of the fuel cycle, uncertainty exists with respect to regulatory limits for off-site releases of radionuclides for the current candidate repository site. We are aware of ongoing efforts to license a geological repository for long-term disposition within the first quarter of the 21st century.
>
> Since appropriate on-site storage of spent fuel assemblies and other radioactive wastes is necessary to prevent environmental impacts, EPA believes the FEIS should provide a thorough consideration of impacts resulting from such storage. Given the uncertainty regarding ultimate disposal, on-site storage may continue for a longer term than currently expected [EPA 2007b].

Section 8 References

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

DOE 2007: U.S. Department of Energy. Yucca Mountain Repository, Licensing. Office of Civilian Radioactive Waste Management. Web page last modified December 2007. http://www.ocrwm.doe.gov/ym_repository/license/index.shtml

DOE 2008a: U.S. Department of Energy. Advanced Fuel Cycle Initiative. Office of Nuclear Energy. http://www.ne.doe.gov/AFCI/neAFCI.html

DOE 2008b: U.S. Department of Energy. Report on Lessons Learned from the NP 2010 Early Site Permit Program, Final Report. Prepared by Energetics Incorporated. March 26, 2008. http://www.ne.doe.gov/pdfFiles/FinalReportonESPLessonsLearned.pdf

EPA 2007a: U.S. Environmental Protection Agency. Uranium Mining Wastes. Web page last updated November 7, 2007. http://www.epa.gov/radiation/tenorm/uranium.html#who_regulates

EPA 2007b: U.S. Environmental Protection Agency. Letter from Heinz J. Mueller, Chief NEPA Program Officer, U.S. EPA Region 4 to Chief, Rules, Directives, and Editing Branch, U.S. NRC, Re: Review and Comments on DEIS for Vogtle Electric Generating Plant Site, Issuance of Early Site Permit (ESP) for Construction and Operation of a New Nuclear Power Generating Facility, NUREG 1872, CEQ 20070386. November 28, 2007

NRC 1996: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

NRC 2001: U.S. Nuclear Regulatory Commission. Regulating Nuclear Fuel, Rev. 1, NUREG/BR-0280. September 2001. Office of Public Affairs. http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0280/br0280r1.pdf

NRC 2006: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site: Final Report. NUREG-1811. Office of New Reactors. December 2006. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1811/draft/sr1811.pdf

NRC 2007a: U.S. Nuclear Regulatory Commission. Stages of the Fuel Cycle. Web page updated February 13, 2007. http://www.nrc.gov/materials/fuel-cycle-fac/stages-fuel-cycle.html

NRC 2007b: U.S. Nuclear Regulatory Commission. High Level Waste Disposal. Web page updated February 13, 2007. http://www.nrc.gov/waste/hlw-disposal.html

NRC 2008: U.S. Nuclear Regulatory Commission. Fact Sheet on Uranium Enrichment. January 2008. Office of Public Affairs. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/enrichment.html

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9. Decontamination and Decommissioning

9. Decontamination and Decommissioning

- At a minimum, does an ESP EIS incorporate by reference the appropriate portions of the decommissioning impact analysis from the Generic EIS on Decommissioning of Nuclear Facilities?
- For NEPA documents at later stages than an ESP, do the actions and conditions at that NPP fall within the bounds of the generic analysis?
- For NEPA documents at later stages than an ESP, has site-specific analysis been documented for endangered and threatened species, environmental justice, and, as appropriate, land use, aquatic ecology, terrestrial ecology, and cultural and historic resources?

NRC regulations define *decommissioning* as ―to remove a facility or site safely from service and reduce residual radioactivity to a level that permits (1) Release of the property for unrestricted use and termination of the license; or (2) Release of the property under restricted conditions and termination of the license" (10 CFR 50.82). Decommissioning activities do not include the removal of spent fuel, which is considered to be an operational activity; the storage of spent fuel, which is addressed in the Waste Confidence Rule (10 CFR 51.23); or the removal and disposal of nonradioactive structures and materials beyond that necessary to terminate the NRC license. Disposal of the nonradioactive hazardous waste that is not necessary for NRC license termination is not considered part of the decommissioning process for which NRC is responsible (NRC 1996, Section 7.1). To be acceptable, decommissioning must be completed within 60 years of the plant ceasing operations. A time beyond that would be considered only when necessary to protect public health and safety in accordance with NRC regulations (NRC 2008).

Decontamination and dismantlement of radioactive structures falls within the scope of decommissioning. The extent of decontamination depends upon the decommissioning strategy chosen.

NRC evaluated the impacts from these activities in the Generic EIS on Decommissioning of Nuclear Facilities, Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors, NUREG-0586 (NRC 2002).

9.1 Decommissioning Strategies

Licensees may choose from three alternative decommissioning strategies: DECON, SAFSTOR, or ENTOMB (NRC 2008). There are several variations to these methods described in NRC's generic decommissioning EIS (NRC 2002, Section 3.2). The three basic strategies are described below:

- Under DECON (immediate dismantlement), soon after the nuclear facility closes, equipment, structures, and portions of the facility containing radioactive contaminants are removed or decontaminated to a level that permits release of the property and termination of the NRC license.

- Under SAFSTOR, often considered "delayed DECON," a nuclear facility is maintained and monitored in a condition that allows the radioactivity to decay; afterwards, it is dismantled.
- Under ENTOMB, radioactive contaminants are permanently encased onsite in a structurally sound material such as concrete and appropriately maintained and monitored until the radioactivity decays to a level permitting restricted release of the property [NRC 2008].

9.2 Addressing Decommissioning in a New NPP EIS

Recent ESP EISs have briefly addressed the impacts of decommissioning within a chapter addressing the fuel cycle, transportation, and decommissioning, follow the detailed analysis of operational impacts. The decommissioning impacts discussion generally has simply incorporated the generic decommissioning EIS‘s findings and stated that, if a reactor type is selected at the CP or COL stage that is not covered by that generic EIS, then impacts would be assessed at that later stage. In NUREG 1555, NRC stated that ―The type of data and information needed will be affected by site and station-specific factors, and the degree of detail should be modified according to the anticipated magnitude of the potential impacts” (NRC 2000, Section 5.9). The applicant must show, at the time of applying for a license, possession, or ―reasonable assurance of obtaining the funds necessary to cover the estimated costs of permanently shutting the facility down and maintaining it in a safe condition” (10 CFR 50.33; NRC 2000, Section 5.9). However, this is a licensing requirement and not a NEPA requirement.

The generic decommissioning EIS predicted only small impacts, but identified two areas that will require site-specific analysis, based on federal requirements: endangered or threatened species, in accordance with the consultation requirements in Section 7 of the Endangered Species Act; and environmental justice, in accordance with Executive Order 12898 (NRC 2002, Executive Summary). The generic EIS identified four additional areas that may require site-specific consideration, particularly from activities occurring outside of the plant‘s operational areas: land use, aquatic ecology, terrestrial ecology, and cultural and historic resources.

For an EIS later than the ESP stage in the licensing process, EPA §309 reviewers should ensure that, if the generic decommissioning EIS‘s analysis is incorporated by reference, that the actions and conditions at the specific NPP fall within the bounds of that analysis, and that site-specific consideration is given to the resources identified in the previous paragraph, as required.

Section 9 References

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NRC 1996: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

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10. Mitigation Actions and Requirements

10. Mitigation Actions and Requirements

- Does the EIS consider mitigation for all impact areas, emphasizing steps to address those impacts with the greatest potential for significance?
- Does the EIS evaluate pollution prevention strategies and technologies beyond those inherent in the proposed NPP design?
- Does the EIS indicate whether implementing a mitigation measure is within NRC‘s jurisdiction?
- Does the EIS demonstrate that affected communities have been involved in developing mitigation measures when necessary?

This section addresses an NPP EIS‘s discussion of the range of mitigation actions, which are intended to minimize the adverse impacts of NPP construction and operation.

10.1 Specifying Mitigation Actions in NPP EISs

Mitigation involves taking steps to avoid, minimize, rectify, reduce, eliminate, or compensate for the impact of an analyzed alternative (40 CFR 1508.20). Examples of mitigation include “design alternatives that would decrease pollution emissions, construction impacts, aesthetic intrusion, as well as relocation assistance, possible land use controls that could be enacted, and other possible efforts.” Mitigation measures discussed in an EIS must cover the range of impacts of the analyzed alternatives, and such measures should be considered even for impacts that by themselves would not be considered “significant” (CEQ 1981).

In an EIS, mitigation could include the following:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.
(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.
(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
(e) Compensating for the impact by replacing or providing substitute resources or environments [40 CFR 1508.20].

In recent ESP EISs, mitigation measures have been incorporated into the discussions of environmental consequences for each resource area in which they are identified (NRC 2006a, NRC 2006b, NRC 2006c). The latest draft revision to NRC‘s “Standard Review Plan for the Environmental Reviews for Nuclear Power Plants,” NUREG 1555 (NRC 2007, Introduction) provides general guidance applicable to all resource areas. The guidance states that mitigation measures should be considered in proportion to the level of the impact when a potentially adverse impact is identified. Also, statements related to mitigation should describe the potential effectiveness of the mitigation measures considered and state whether mitigation measures are warranted or not. The guidance differentiates mitigation and avoidance:

> MITIGATION: Impact mitigation is the process of modifying a design or practice (either a construction practice or an operating procedure) to lessen its environmental impact. Successful mitigation may reduce the impact level characterization under NRC's SMALL/MODERATE/ LARGE impact characterization approach. Mitigation measures should be considered even for impacts considered to be SMALL.
>
> AVOIDANCE: Impact avoidance is the process of using an alternative design or practice that avoids the identified adverse impact. Note that alternatives may have adverse impacts of their own and must be evaluated to ensure that any such impacts can be successfully mitigated [NRC 2007, Introduction].

In accordance with NRC guidance (NRC 2000, NRC 2007, Sections 4.6 and 5.10 in each), these recent ESP EISs also summarized ―Measures and Controls to Limit Adverse Impacts" at the conclusion of the construction impacts and operational impact sections. NRC's guidance calls for tabulating the adverse impacts of construction and operation, identified in the applicant's environmental report, for which measures and controls to limit the impacts can be applied, and to evaluate the applicant's commitment related to each impact. The recent ESP EISs included a general discussion of measures and controls to limit adverse impacts, and referred to their environmental reports for the required tables.

Accident mitigation is presented separately. EISs for new NPPs should assess environmental impacts of postulated accidents, and NRC considers the particular identification and evaluation of severe accident mitigation alternatives (see Section 6.8 of this guidance document).

10.2 Examples of Impacts for Which Mitigation Should be Considered

The major construction required for a new NPP has great potential to impact sensitive resources in the area, including cultural resources, threatened and endangered species, critical habitat, and wetlands. For impacts from activities other than preconstruction, because of the length of the construction period and types of equipment used, significant impacts to surrounding public and to workers (such as noise, fugitive dust, traffic, and safety) may also result. These are the types of impacts for which mitigation should be considered, and the EIS should include a detailed mitigation discussion.

For NPP operation, water use and aquatic ecosystem impacts are areas of potentially significant impacts that can be considerably lessened by appropriate mitigation. A proposal for an NPP may include efforts to help ensure water supplies last, although it may be included as part of the proposed alternatives rather than as a separately identified mitigation action. For example, an NPP could obtain a right to a local water supply by offering to clean it up and giving some back to local government for other uses. Water intake and discharge structures, and their operation, can be designed with specific consideration for minimizing effects on surface water and aquatic habitat.

10.3 Reviewing Mitigation Actions in an EIS

These recommendations were adapted from DOE (2004).

1. The EIS should consider mitigation for all impact areas, emphasizing steps to address those impacts with the greatest potential for significance.

2. The EIS should evaluate pollution prevention strategies and technologies beyond those inherent in the proposed NPP design.

3. The EIS should indicate whether implementing a mitigation measure is within NRC's jurisdiction and should identify any external parties (such as state, local, or tribal government agencies; land owners) who must be involved in establishing or implementing the mitigation.

4. The EIS should demonstrate that affected communities have been involved in developing mitigation measures when necessary.

10.4 EPA Comments Regarding Mitigation

The potential application of mitigation measures discussed in an EIS should be considered in determining EPA's rating of the environmental impact of the proposed action (see Section 1.3 of this guidance document). An EPA review may disclose opportunities for application of mitigation measures. Where mitigation could be accomplished with no more than minor changes to the proposed action, an EPA rating of ―Lack of Objections" to environmental impacts is appropriate. When avoidance of the impact is the only option, a rating of ―Environmental Concerns" or ―Environmental Objections" may be given.

EPA's 309 Manual (EPA 1984, as updated by EPA 2007a) includes several points regarding EPA comments related to mitigation:

- EPA's comments on a Draft EIS should include, if appropriate, measures to avoid or minimize damage to the environment, or to protect, restore, and enhance the environment. Suggestions for mitigation should be oriented toward selection of mitigation measures that are technically feasible, would have long-term effectiveness, and have a high likelihood of being implemented [EPA 1984, Chapter 4.3.b].

- If a Final EIS identifies the agency's preferred alternative for the first time or modified the previously identified preferred alternative, EPA's review should include consideration of any additional specific mitigation measures that could reduce any adverse impacts of that alternative [EPA 1984, Chapter 6.3.b].

- When mitigation measures are recommended, the comment letter should suggest that the lead agency include these measures in their Record of Decision as specific conditions of the license [EPA 1984, Chapter 6.3.b].

- Where the adoption and implementations of EPA's recommended mitigation measures are directly related to the acceptability of the action, the comment letter should include a

> request that the lead agency keep EPA informed of progress in carrying out the mitigation measures proposed by the EPA [EPA 1984, Chapter 6.3.b].

However, 309 reviewers should be aware that NRC's position is that they have very limited authority in terms of placing conditions for the protection of the environment on licenses.

An example EPA comment identifying specific impacts for which mitigation is recommended is shown below. The comment is in reference to the Final EIS for an ESP at the North Anna site:

> As described in the FEIS, the ESP would authorize a plant parameter envelope that would potentially impact approximately 7.14 acres of wetlands, 5,500 linear feet of stream and 2.49 acres of open water. If Dominion Nuclear North Anna, LLC were to proceed with this project, EPA recommends that mitigation be considered for these impacts. All of the relevant resource agencies should be engaged early in the process of developing any mitigation package. EPA also recommends that NRC include a commitment regarding this mitigation in any subsequent Record of Decision [EPA 2007b].

Section 10 References

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CEQ 1981: Council on Environmental Quality. Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations. Memorandum dated March 16, 1981. 46 Federal Register 18026 (March 23, 1981). http://www.nepa.gov/nepa/regs/40/40p1.htm

DOE 2004: U.S. Department of Energy. Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, Second Edition. Office of NEPA Policy and Compliance. December 2004. http://www.eh.doe.gov/nepa/tools/guidance/volume2/2-10-greenbook-recommendations.pdf

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EPA 2007a: U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance. Memorandum: Errata for the Policy and Procedures for the Review of Federal Actions Impacting the Environment. From Anne Norton Miller, Director, OFA. July 19, 2007.

EPA 2007b: Letter from William Arguto, U.S. EPA NEPA Team Leader, to Mr. Jack Cushing, U.S. NRC re: Final Environmental Impact Statement (FEIS) for an Early Site Permit (ESP) at the North Anna ESP Site –NRUEG 1811 (North Anna ESP Project, CEQ No 20060524), February 5, 2007.

NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2006a: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site: Final Report. NUREG-1811. Office of New Reactors. December 2006. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1811/draft/sr1811.pdf

NRC 2006b: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site - Final Report, NUREG-1815. Office of New Reactors. Washington, DC. July 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1815/sr1815v1.pdf

NRC 2006c: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site, NUREG-1817. Office of New Reactors. Washington, DC. April 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1817

NRC 2007: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555, draft revisions. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html

11. Cumulative Impacts

- Does the EIS consider the potential for cumulative effects of the proposed action and other activities in the area under consideration, including pre-construction activities?
- If applicable, have potential cumulative impacts from a proposed facility and operation of a co-located existing facility been considered?

11. Cumulative Impacts

CEQ regulations define cumulative impacts as ―the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR 1508.7). Agencies are not required to list or analyze the effects of individual past actions unless such information is necessary to describe the cumulative effect of all past actions combined (CEQ 2005).

11.1 Recommendations for Review of Cumulative Impacts

The following recommendations were adapted from DOE (2004):

- The EIS should address cumulative impacts for each analyzed alternative where understanding the cumulative impacts may help distinguish among alternatives.
- The EIS should evaluate potential cumulative impacts for all resources for which direct and indirect impacts were evaluated for construction and operation of a NPP.
- The EIS should consider impacts from relevant past, present, and reasonably foreseeable future actions that occur within defined geographic boundaries for as long as they are reasonably foreseeable for the alternative. Future cumulative impacts should be foreseeable for construction, operation, and decommissioning. Past activities may include impacts from power plants at brownfield sites. Information regarding past actions is necessary if it is useful and relevant to the required analysis of cumulative effects (CEQ 2005).
- The EIS should identify pathways and potential impacts appropriate for the cumulative impacts analysis. The sources of impacts on a resource may be more diverse when analyzing cumulative impacts than project-specific impacts, and the nature of impacts may differ. For example, the cumulative impacts on fish might be affected by effluent released from the alternative plus non-NPP sources, such as agricultural runoff, erosion from construction activities, or effluent from other facilities, including some yet to be built. As another example, the cumulative impact of NPP operation on a listed species may need to be considered in terms of the specific stresses that led to that species' need for protection.
- The EIS should consider cumulative impacts when developing mitigation.

11.2 Potential Cumulative Impacts of New NPP Construction and Operation

While cumulative impacts should be addressed for all impact areas identified for construction and operation of a NPP, certain resources are more likely to be associated with cumulative impacts. EPA §309 reviewers should consider the following points:

- The co-location of plants could contribute to potential cumulative impacts that will need to be addressed. This includes the combined impacts of new plant construction on existing plant operations, and combined impacts when both plants are operating. Combined impacts of operation include traffic/congestion, noise, and socioeconomic effects (beneficial and adverse).

- In order to conduct the cumulative impact assessment, the NPP EIS should identify all site preparation activities as well as those outside of NRC‘s jurisdiction (considered to be ―pre-construction” as defined in 10 CFR 50.10). The impacts from pre-construction, LWA-authorized construction activities, and the activities of the proposed action and alternatives must be considered together to provide an adequate assessment of cumulative impacts in an ESP or COL EIS.

- All preceding and related NEPA reviews conducted for the proposed NPP should be referenced in the EIS, with their results incorporated by reference and impacts considered within the analysis of cumulative impacts.

- Cumulative impacts from other NPP-related construction (such as constructing a reservoir for water storage or constructing an onsite treatment facility if cooling water needs to be treated before input to the plant) should be addressed. Draft guidance for addressing cumulative impacts from construction has been added to NRC‘s Standard Review Plan for the Environmental Reviews for Nuclear Power Plants (NRC 2007, Section 4.7).

- Radiological or other health effects may occur in populations affected by cumulative or multiple exposures to environmental hazards.

- Cumulative impacts from the nuclear fuel cycle are treated generically through the use of Table S-3 (see Section 8 of this guidance document). Cumulative impacts related to the fuel cycle will need to be identified for other-than-light water reactor types.

- Other currently planned industrial, commercial, or public installations that would consume water within the general vicinity should be considered (NRC 2006, Section7.3).

Section 11 References

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DOE 2004: U.S. Department of Energy. Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, Second Edition. Office of NEPA Policy and Compliance. December 2004. http://www.gc.energy.gov/NEPA/documents/green_book2004_12_30_final.pdf

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12. Irreversible and Irretrievable Commitment of Resources

- Does the EIS evaluate irreversible and irretrievable commitments of resources?

12. Irreversible and Irretrievable Commitment of Resources

12.1 Irreversible Commitment of Resources
12.2 Irretrievable Commitment of Resources

Section 102(2)(C) of NEPA requires evaluation of any irreversible or irretrievable commitments of resources. NRC regulations at 10 CFR Part 51 state that any irreversible or irretrievable commitments of resources which would be involved in the alternative, should it be implemented, must be included as environmental consequences.

12.1 Irreversible Commitment of Resources

Irreversible commitments of resources are commitments of the environment that cannot be altered at some later time to restore the present order of environmental resources. The NPP EIS should include a determination of whether the adverse impacts of construction and operation constitute any irreversible commitments of resources. Irreversible commitments should be considered for the following categories:

- land use
- hydrological and water use
- ecological (terrestrial and aquatic)
- socioeconomic
- radiological
- atmospheric and meteorological [NRC 2000, Section 10.2]

12.2 Irretrievable Commitment of Resources

―Irretrievable" applies to material resources and concerns commitments of materials that, when used, cannot by practical means be recycled or restored for other use. Permanent resource commitments associated with NPP operation include uranium and land (NRC 2000, Section 10.2).

Because granting an ESP does not authorize operation of the NPP, evaluation of the irretrievable commitment of uranium may be excluded from an ESP EIS, but would be included in a COL or OL EIS. The consequences of irretrievable use of uranium for reactor fuel depend upon uranium supplies. NRC‘s Standard Review Plan for the Environmental Reviews for Nuclear Power Plants suggests including the following statement, updated as necessary to reflect the current DOE resource analysis; reviewers should expect to find a current version of the statement in a COL or OL EIS:

> U.S. Department of Energy resource estimates indicate that sufficient uranium resources exist in the United States to fuel all operating reactors, reactors under construction, and reactors being planned for the next 10 years at a U_3O_8 cost (1996 dollars) of $30.00/lb or less. These quantities of uranium can be supplied from the resource categories designated as reserves and estimated additional resources, the two most certain resource categories [NRC 2000, Section 10.2].

Irretrievable commitments of resources that would occur during construction of a proposed NPP generally would be similar to other major construction projects, including concrete, steel, and other building materials. Information on use of these materials may not be detailed at the ESP stage since they depend on the reactor design selected but would be estimated in a COL EIS.

Section 12 Reference

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NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

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13. Short-Term Uses vs. Long-Term Productivity

➢ Does the EIS evaluate short-term uses vs. long-term productivity?

Section 102(2)(C)(iv) of NEPA requires that an EIS include information on the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity. NRC regulations at 10 CFR Part 51 parallel this requirement for NRC EISs.

The balance or trade-off between short-term uses and long-term productivity needs to be defined in relation to the proposed activity. Each resource, of necessity, has to be provided with its own definitions of short- term and long-term (FWS undated).

NRC‘s Standard Review Plan for the Environmental Reviews for Nuclear Power Plants (NRC 2000) defines, for the purpose of environmental reviews, —short term” to represent the period from start of construction to end of plant life, including prompt decommissioning, and —long term” to represent the period extending beyond the end of plant life, including the period up to and beyond that required for delayed plant decommissioning.

The NRC guidance states that analysis of the relationship between short-term uses and long-term productivity should be based on the tabulation of unavoidable adverse environmental impacts and irreversible and irretrievable commitments of resources. The guidance suggests that standard language be used:

> Unless the reviewer has identified other long term environmental impacts, the following input to the EIS should be used:
>
> - The local use of the human environment by the proposed project can be summarized in terms of the unavoidable adverse environmental impacts of construction and operation and the irreversible and irretrievable commitments of resources. With the exception of the consumption of depletable resources as a result of plant construction and operation, these uses may be classed as short term. The principal short term benefit of the plant is represented by the production of electrical energy; and the economic productivity of the site, when used for this purpose, will be extremely large compared with the productivity from agriculture or from other probable uses for the site.
>
> - The maximum long term impact to productivity will result when the plant is not dismantled at the end of the period of plant operation, and consequently the land occupied by the plant structures will not be available for any other use. However, the enhancement of regional productivity resulting from the electrical energy produced by the plant is expected to result in a correspondingly large increase in regional long term productivity that would not be equaled by any other long term use of the site. In addition, most long term impacts resulting from land-use preemption by plant structures can be eliminated by removing these structures or by converting them to other productive uses.
>
> - The staff concludes that the negative aspects of plant construction and operation as they affect the human environment are outweighed by the positive long term enhancement of regional productivity through the generation of electrical energy [NRC 2000, Section 10.3].

In recent ESP EISs, this topic was addressed in reference to the limited site preparation and construction activities that would be authorized by the ESP. In an EIS for a CP or COL, a more extensive statement (perhaps illustrated by the standard NRC language above, if appropriate) would be included.

Section 13 References

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NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

FWS undated: U.S. Fish and Wildlife Service. NEPA Reference Handbook (Glossary). http://www.fws.gov/r9esnepa/NEPA_HANDBOOK2.pdf

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14. Alternatives

14. Alternatives

- Do the proposed action and reasonable alternatives achieve the stated purpose and need?
- Is the proposed action clearly defined and described?
- Is the no action alternative clearly identified and described in sufficient detail so that its scope is clear and potential impacts can be identified?
- Has a reasonable range of alternatives been considered?
  - Has the region of interest been identified and does it appear reasonable, given the type of plant proposed and the service area it will be supporting?
  - Has the range of sites been unduly narrowed to predetermine the outcome of the alternative site review?
  - Are the alternative sites identified the best that can be reasonably be found for the siting of a nuclear power plant, or have potential sites been omitted?
  - Have existing power plants within the region of interest been considered, as well as potential greenfield, brownfield, and other sites?
  - Has sufficient information been presented to explain why alternatives eliminated from detailed study were eliminated?
- Are the alternatives treated fairly and in an even-handed manner? Have the candidate sites been evaluated in sufficient detail to support selection of the proposed action and alternative sites?
- Are the environmental impacts of alternatives presented in a comparative form to sharply define the issues and provide a clear basis for choice among alternatives? Is sufficient information presented to allow the decision maker or other readers to evaluate differences among them?
- Has the analysis shown that none of the alternative sites is obviously superior to the proposed site?

NEPA requires all federal government agencies to study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources. CEQ‘s regulations direct all agencies to use the NEPA process to identify and assess the reasonable alternatives to proposed actions that will avoid or minimize adverse effects of these actions upon the quality of the human environment (40 CFR 1500.2(e)).

NRC regulations (10 CFR 51.45(3)) incorporate the language from the NEPA statute and, in keeping with CEQ‘s regulations, state that –to the extent practicable, the environmental impacts of the proposal and the alternatives should be presented in comparative form.” NRC regulations specifically require that the environmental report submitted in conjunction with an application for an ESP include an evaluation of alternative sites to determine whether there is an "obviously superior" alternative to the site proposed (10 CFR 52.17(a)(2) referring to 10 CFR 51.50 (b) (1)).

14.1 Alternatives in New NPP EISs

The alternatives should include the no action alternative and alternatives that meet the purpose and need as described in the EIS, such as energy alternatives, alternative sites (simply referencing the ESP EIS if no new sites are considered), and alternative plant systems for functions such as heat dissipation and water circulation (NRC 2000, NRC 2007a, both Appendix A).

In a challenge that the NRC failed to consider reasonable energy efficiency alternatives in an EIS for an ESP for the Exelon Generation Company‘s Clinton nuclear power station site, the Seventh Circuit Court of Appeals stated that consideration of energy efficiency alternatives was not required because the applicant‘s purpose, which was adopted by the NRC, was broad enough to ―permit consideration of a host of energy generating alternatives” (*Environmental Law and Policy Center v. U.S. Nuclear Regulatory Commission,* 470 F.3d 676, 684 (7th Cir. 2006)). Moreover, the Court noted that the NRC‘s conclusion ―that NEPA did not require consideration of energy efficiency alternatives when [the applicant] was in no position to implement such measures” was reasonable.

Despite the conclusion of this case, EPA believes that energy efficiency/conservation should be evaluated in an NPP EIS, as appropriate.

14.1.1 No Action Alternative

CEQ regulations (40 CFR 1502.14(d)) require the alternatives analysis in the EIS to include the alternative of no action. In the case of federal decisions on proposals for projects, ―no action‘ means the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward. Where a choice of no action by the agency would result in predictable actions by others, this consequence of the no action alternative should be included in the analysis” (CEQ 1981, Question 3).

> In recent EISs for ESPs at the North Anna, Grand Gulf, and Exelon sites, the no action alternative referred to a scenario in which the NRC would deny the ESP request. In these cases, the impacts from preliminary construction activities authorized under 10 CFR 52.17(c) would not occur, nor would the benefits of an ESP license occur (early resolution of siting and environmental issues, the ability to bank sites, and facilitation of future decisions on whether to build new nuclear plants) (NRC 2006a, NRC 2006b, NRC 2006c, Section 8.1 in each).

NRC guidance states that the no action alternative can be described by a determination of the forecast energy consequences if the project is not completed (NRC 2000, Section 9.1). The consequences can be determined by the analyses concerning the need for power and energy supply alternatives.

14.1.2 Energy Alternatives

NRC guidance calls for two categories of energy alternatives to be addressed:

1. alternatives not requiring new generating capacity
2. alternatives requiring new generating capacity

NRC guidance also calls for an assessment of competitive alternative energy sources and systems (NRC 2007a, Section 9.2). Energy alternatives need not be addressed in an ESP EIS (NRC 2007a, Section 9.2.1); however, they were addressed in the Grand Gulf ESP EIS (NRC 2006c). Detailed information and evaluation criteria for energy alternatives analysis are provided in recently updated sections of NUREG 1555 (NRC 2007a, Sections 9.2.1 – 9.2.3); the following paragraphs summarize the new information.

14.1.2.1 Alternatives Not Requiring New Generating Capacity

The alternatives presented in this section should include either supplying the electrical energy demand without constructing new generating capacity (for example, purchasing from another utility) or initiating energy conservation (including energy efficiency) measures that would avoid the need for the plant. Information should be systematic, comprehensive, subject to confirmation, and responsive to forecasting uncertainty. This is not applicable to applications for ESPs that do not include an analysis of energy alternatives (NRC 2007a, Section 9.2.1).

14.1.2.2 Alternatives Requiring New Generating Capacity

The alternatives presented in this section should include either alternatives not yet commercially available, fossil fuels (taking into account national policy regarding their use as fuels), and alternatives uniquely available within the region (such as hydropower and geothermal). The energy sources listed below should be considered; however, they should be categorized as either competitive or non-competitive (according to criteria laid out in NUREG 1555). If they are determined to be non-competitive, reasons for dismissing them from further analysis should be provided:

- wind
- geothermal
- natural gas
- hydropower
- advanced nuclear
- municipal solid wastes
- biomass
- coal
- photovoltaic cells
- solar thermal power
- wood waste
- energy crops
- other advanced systems (such as fuel cells, synthetic fuels, or other) [NRC 2007a, Section 9.2.2]

> Note that the term “competitive,” added in the 2007 update to NUREG 1555, is defined as “…one that is feasible and compares favorably with the proposed project in terms of environmental and health impacts. If the proposed project is intended to supply baseload power, a competitive alternative would also need to be capable of supplying baseload power. A competitive alternative could be composed of combinations of individual alternatives.”

NRC‘s ―Generic Environmental Impact Statement for License Renewal of Nuclear Plants," NUREG-1437 (NRC 1996, Section 8.3) includes a discussion of most of the energy alternatives listed above and provides a comparison of environmental impacts.

14.1.2.3 Assessment of Competitive Alternative Energy Sources and Systems

In this evaluation, the EIS should determine if one or more of the competitive (as defined above) alternatives can be expected to provide an appreciable reduction in overall environmental impact or offer solutions to potential adverse impacts predicted for the proposed project for which no mitigation procedure could be identified. It should also include an economic assessment if a competitive environmentally preferable source is identified (NRC 2007a, Section 9.2.3).

14.1.3 Alternative Sites

Alternative sites could include existing power plants within the region of interest, as well as potential greenfield sites (containing no nuclear plants, non-nuclear power plants, or non-power nuclear facilities), brownfields (nuclear and otherwise, owned by other power producers), and other sites. These may also be identified in the EIS as part of the alternatives considered but eliminated from detailed analysis. In accordance with NRC review guidelines (NUREG 1555), the NRC staff should analyze candidate sites suitable for the size and type of nuclear power plant proposed by the applicant within the region of interest, or geographic area considered in search for possible sites.

When publishing the final 10 CFR Part 51 rule on ―Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions and Related Conforming Amendments," NRC explained why they consider alternative sites:

> The reason for considering alternative sites is that many environmental impacts can be avoided or significantly reduced through proper selection of the location for a new generating facility. These significant impacts which can be avoided or reduced are also readily detected at the planning stage of a power plant. For this reason alternative site reviews are encouraged as early as possible in the process of licensing a power plant and the use of reconnaissance-level information for making the comparative analysis is urged [as cited in NRC 2002].

NRC uses a multi-step process to select alternative sites for consideration in an EIS. According to NRC‘s draft revised review guide (NRC 2007a, Section 9.3), the analysis of alternative sites includes evaluation of the applicant‘s process and results related to the selection of the region of interest, candidate areas, potential sites, candidates sites, and the selection of the proposed site, and a reasonable number of alternative sites from among the candidate sites. When one or more environmentally preferable alternative sites are identified, cost-benefit techniques and other procedures should be used to determine if any environmentally preferable site can be shown to be obviously superior to the applicant‘s proposed site (NRC 2007a, Section 9.3). The appendix to the revised review guide section lists evaluation factors and provides a flow chart describing the site selection process.

Based on guidance given in NUREG 1555 (NRC 2000, 2007a, Section 9.3 in both) and summarized in the Commission Order for the North Anna ESP (NRC 2007b), the EIS should include a thorough discussion of the site selection process, whether a new or pre-existing plant site is being proposed, as follows:

> But regardless of whether the applicant is proposing a new or pre-existing plant site, the Staff's [NRC] evaluation ... of the applicant's site selection process should include consideration of both the process (i.e., methodology) used by the applicant and the reasonableness of the product (e.g., potential sites) identified by that process." The purposes are to determine whether the "candidate areas" identified by the applicant represent a reasonably complete list of such areas within the identified ―region of interest" and, more particularly, to determine if the applicant has employed an "adequate, well documented process for screening candidate sites" such that "there is reasonable assurance that no potential alternative sites...have been omitted. The criteria for selecting candidate areas and candidate sites are essentially the same. The ESRP then states that, as a general matter, "the identification of .... three to five alternative sites in addition to the proposed site could be viewed as adequate [NRC 2007b].

Accepting the NRC‘s basis for alternative site evaluation as described in the order, EPA §309 reviewers may wish to consider whether the following questions have been adequately addressed in the EIS:

1. Has the region of interest been identified and does it appear reasonable, given the type of plant proposed and the service area it will be supporting?
2. Has the applicant followed a multi-step process consistent with the steps outlined above?
3. Has a clear methodology been identified and implemented?
4. Have the candidate sites been evaluated in sufficient detail to support selection of the proposed action and alternative sites?
5. Has a reasonable number of alternative sites been identified and evaluated?

14.1.4 Alternative Plant Systems

This section should describe alternative heat dissipation systems and circulating water systems. The depth of the analysis should be governed by the nature and magnitude of a proposed system‘s impacts. NUREG 1555 discusses methods for screening and evaluating alternatives (NRC 2000, 2007a, Section 9.4 in both). Alternative heat dissipation systems should be evaluated in terms of land use, water use, atmospheric effects, thermal and physical effects, noise levels, aesthetics, recreational benefits, operating and maintenance experience, generating efficiency, costs, and other considerations. Alternative circulating water systems components considered should include intake systems, discharge systems, water supply, and water treatment systems. Each should be analyzed for construction impacts to aquatic ecology, water use impacts, compliance with regulations, and costs (NRC 2007a, Section 9.4.3).

14.2 EPA Comments Regarding Alternatives

EPA‘s review of alternatives generally occurs at the Draft EIS phase. EPA‘s 309 Manual (EPA 1984, as updated by EPA 2007) calls for reviewers to ―review the complete range of alternatives, identifying those that are environmentally unacceptable to EPA and identifying EPA's preferred alternative, if necessary. If significant impacts are associated with the proposal and they cannot be adequately mitigated, EPA's comments should suggest an environmentally preferable alternative, including if necessary, a new alternative. The suggested alternatives should be both reasonable and feasible. In this context, such an alternative is one that is practical in the technical, economic, and social sense, even if the alternative is outside the jurisdiction of the lead agency" (EPA 1984).

> The presentation of alternatives is key to the EIS reviewer's determination of the adequacy of the Draft and Final EIS. An EIS is considered ―adequate" if ―EPA believes the draft EIS adequately sets forth the environmental impact(s) of the preferred alternative and those of the alternatives reasonably available to the project or action" (EPA 1984).

Section 14 References

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CEQ 1981: Council on Environmental Quality. Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations. 46 Federal Register 18026 (March 16, 1981). http://www.nepa.gov/nepa/regs/40/40p1.htm

EPA 1984 U.S. Environmental Protection Agency. Policy and Procedures for the Review of Federal Action Impacting the Environment. October 3, 1984. http://www.epa.gov/compliance/resources/policies/nepa/nepa_policies_procedures.pdf

EPA 2007: U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance. Memorandum: Errata for the Policy and Procedures for the Review of Federal Actions Impacting the Environment. From Anne Norton Miller, Director, OFA. July 19, 2007.

NRC 1996: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/

NRC 2000: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

NRC 2002: Policy Issue Notation Vote for the Commissioners, from William D. Travers, Executive Director for Operations (SECY-02-0175) September 27, 2002 Referencing: Denial Of Petition For Rulemaking To Eliminate Review Of Alternative Sites, Alternative Energy Sources And Need For Power In Nuclear Power Reactor Siting And Licensing Reviews (PRM-52-2) http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2002/secy2002-0175/2002-0175scy.html

NRC 2006a: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site: Final Report. NUREG-1811. Office of New Reactors. December 2006. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1811/draft/sr1811.pdf

NRC 2006b: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site - Final Report, NUREG-1815. Office of New Reactors. Washington, DC. July 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1815/sr1815v1.pdf

NRC 2006c: U.S. Nuclear Regulatory Commission. Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site, NUREG-1817. Office of New Reactors. Washington, DC. April 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1817

NRC 2007a: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555, draft revisions. July 2007. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html

NRC 2007b: U.S. Nuclear Regulatory Commission. Memorandum and Order in the Matter of Dominion Nuclear North Anna, LLC (Early Site Permit for North Anna ESP Site), Docket No. 52-008-ESP. November 20, 2007.

U.S. Court of Appeals 2006: United States Court of Appeals for the Seventh Circuit, No. 06-1442, *Environmental Law and Policy Center v. U. S. Nuclear Regulatory Commission,* 470 F.3d 676 (7th Cir. 2006). Appeal from the U.S. Nuclear Regulatory Commission. No. CLI-05-29. http://caselaw.lp.findlaw.com/data2/circs/7th/061442p.pdf

15. Comparison of Proposed Action and Alternatives

➢ Does the EIS present a comparison of the environmental impacts by alternative?

NRC (2000) states that the alternatives discussion ―is the heart of the environmental impact statement. It will present the environmental impacts of the proposal and the alternatives in comparative form.” This section should serve as a useful tool to facilitate the readers‘ evaluation and comparison of analysis and descriptions detailed elsewhere in the document. Generally, this section of an EIS presents the comparison of alternatives in a table with a brief narrative summary. The following points for review note specific issues related to evaluation of NPP EISs:

- The reader will generally find the comparison of the environmental impacts of the proposed action and alternatives in Chapter 9 of an NPP EIS, if it follows the structure recommended in NRC‘s ―Standard Review Plan for the Environmental Reviews for Nuclear Power Plants” (NRC 2000) and its most recently revisions (NRC 2007).

- No new information should be introduced in the comparison that has not been included in the impacts analysis.

- Findings of impacts labeled as small, moderate, or large (consistent with NRC‘s impact assessment approach, described in Section 5) are likely to be used; the information presented should be consistent with the impact analyses.

- The comparison should be thorough in terms of all alternatives and relevant details presented in the EIS.

- Impacts at a specific site may differ for different scales of evaluation. For example, socioeconomic impacts could be small at a regional level and large at a local level if the closest town to the site is small, the in-migrating workforce is large, and the majority of the incoming workforce elects to live in the closest town. These differences, if not presented in tabular form, should be included in the discussion.

Section 15 References

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NRC 2007: U.S. Nuclear Regulatory Commission. Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, NUREG 1555, draft revisions. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html

16. List of EPA Points of Contact and Associate Reviewers

Office of Enforcement and Compliance Assurance, Office of Federal Activities, NEPA Compliance Division

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Marthea Rountree (202) 564-7141

Office of Air and Radiation, Office of Radiation and Indoor Air (ORIA), Radiation Protection Division

Juan Reyes ((202) 343-9290 (Director)

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Dan Schultheisz (202) 343-9349 (Yucca Mountain)

Ray Clark (202) 343-9198 (Yucca Mountain)

Loren Setlow (202) 343-9445 (Uranium)

Office of Water

OWM, WPD, IB: Jamie Hurley (202) 564-1709 (Section 316(b))

Region 4: Karrie-Jo Shell (404) 562-9308 (EPAHQ NPDES Energy contact)

GWDW, DWPD: Jeff Jollie (202) 564-3886 (DOE, NRC)

GWDW, DWPD: Dr. Marilyn Ginsberg (202) 564-3881 (NRC)

Office of Solid Waste and Emergency Response RCRA Permitting

OSW/PSPD/CAPB: Ernesto ―Ernie” Brown (703) 308-8608 (Yucca Mountain)

Regional Points of Contact

1 Tim Timmermann (617)-918-1025 (Office of Environmental Review)
Dan Brown (617) 918-1048 (ORIA)

2 Lingard Knutson (212) 637-3747 (Environmental Review Section)
Paul A. Giardina (212) 637-4010 (ORIA)

3 Kevin Magerr (215) 814-5724 (Environmental Programs Branch/ NEPA Team)
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4 Ramona McConney (404) 562-9615 (NEPA Program Office)
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5 Anna Miller (312) 886-7060 (NEPA Implementation Section)
Carl Nash (312) 886-6030 & Jack Barnette (312) 886-6175 (ORIA)

6 Mike Jansky (214) 665-7451 (Environmental Review/NEPA Compliance)
Missy Milbeck (214) 665-6540 & George Brozowski (214) 665-8541 (ORIA)

7 Larry Shepard (913) 551-7441 (Environmental Services Division/NEPA Team)
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Janemarie Newton (303) 312-6348 (ORIA)

9 Jeanne Dunn Geselbrecht ((415) 972-3853 (Environmental Review Office)
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10 Theo Mbabiye (206) 553-6322 (NEPA Review Unit)
Davis Zhen (206) 553-7660 (ORIA)

17. Annotated Bibliography

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CEQ 1981: Council on Environmental Quality. Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations. Memorandum. 46 Federal Register 18026 (March 16, 1981). http://www.nepa.gov/nepa/regs/40/40p1.htm: The Council on Environmental Quality, as part of its oversight of implementation of the National Environmental Policy Act, held meetings in the ten Federal regions with Federal, State, and local officials to discuss administration of the implementing regulations. The forty most asked questions were compiled in a memorandum to agencies for the information of relevant officials. In order efficiently to respond to public inquiries this memorandum is reprinted in the Federal Register.

CEQ 1993: Incorporating Biodiversity Considerations into Environmental Impact Analysis under the National Environmental Policy Act. January 1993. http://www.eh.doe.gov/nepa/tools/guidance/Guidance-PDFs/iii-9.pdf: This report presents the results of consultations by the Council on Environmental Quality (CEQ) concerning the consideration of biological diversity analyses prepared under NEPA. This report is intended to provide background on the emerging, complex subject of biodiversity, outline some general concepts that underlie biological diversity analysis and management, describe how the issue is currently addressed in NEPA analyses, and provide options for agencies undertaking NEPA analyses that consider biodiversity.

CEQ 1997: Council on Environmental Quality, Environmental Justice Guidance under the National Environmental Policy Act, December 10, 1997. http://www.epa.gov/compliance/resources/policies/ej/ej_guidance_nepa_ceq1297.pdf: CEQ, in consultation with EPA and other affected agencies, developed this guidance to further assist Federal agencies with their NEPA procedures so that environmental justice concerns are effectively identified and addressed. To the extent practicable and permitted by law, agencies may supplement this guidance with more specific procedures tailored to particular programs or activities of an individual department, agency, or office.

CEQ 2005: Council on Environmental Quality. Guidance on the Consideration of Past Actions in Cumulative Effects Analysis. Memorandum from James L. Connaughton, Chairman. June 24, 2005. http://www.nepa.gov/nepa/regs/Guidance_on_CE.pdf: In this Memorandum, the Council on Environmental Quality (CEQ) provides guidance on the extent to which agencies of the Federal government are required to analyze the environmental effects of past actions when they describe the cumulative environmental effect of a proposed action in accordance with Section 102 of the National Environmental Policy Act (NEPA), 42 U.S.C. § 4332, and the CEQ Regulations for Implementing the

Procedural Provisions of NEPA, 40 C.F.R. parts 1500-1508. CEQ's interpretation of NEPA is entitled to deference. *Andrus v. Sierra Club*, 442 U.S. 347, 358 (1979).

CRS 2006: Congressional Research Service Report for Congress--Energy Policy Act of 2005: Summary and Analysis of Enacted Provisions. March 8, 2006. http://ncseonline.org/NLE/CRSreports/06Apr/RL33302.pdf: A summary and analysis of enacted provisions of the Energy Policy Act of 2005 (P.L. 109-58), signed by President Bush on August 8, 2005. The report includes a discussion of title 6, ―Nuclear Matters”.

CRS 2006: Congressional Research Service. Nuclear Power Plants: Vulnerability to Terrorist Attack. M. Holt and A. Andrews. Resources, Science, and Industry Division. Updated October 4, 2006. http://stinet.dtic.mil/cgi-bin/GetTRDoc?AD=ADA471755&Location=U2&doc=GetTRDoc.pdf: Protection of nuclear power plants from land-based assaults, deliberate aircraft crashes, and other terrorist acts has been a heightened national priority since the attacks of September 11, 2001. The Nuclear Regulatory Commission (NRC) has strengthened its regulations on nuclear reactor security, but critics contend that implementation by the industry has been too slow and that further measures are needed. Several provisions to increase nuclear reactor security were included in the Energy Policy Act of 2005, signed August 8, 2005. The law requires NRC to conduct ―force-on-force” security exercises at nuclear power plants at least once every three years and to revise the ―design-basis threat” that nuclear plant security forces must be able to meet, among other measures.

DOE undated: U.S. Department of Energy, Energy Information Administration. New Reactor Designs. http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss_2.html: This article summarizes nuclear reactor designs that are either available or anticipated to become available in the United States by 2030. Criteria for including reactors are: (1) participation or likely participation in the U.S. Nuclear Regulatory Commission's design certification or pre-certification programs; and (2) inclusion under the Generation IV International Forum (GIF) program for longer-term reactor development.

DOE 2001: A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010 http://www.ne.doe.gov/nerac/neracPDFs/ntdroadmapvolume1.pdf : The U.S. Department of Energy (DOE) has been working with the nuclear industry to establish a technical and regulatory foundation for the next generation of nuclear plants. The DOE Generation IV (Gen IV) Program is assembling a 30-year road map for advanced plant and fuel cycle research and development. To complement Gen IV, DOE also organized a Near-Term Deployment Group (NTDG) to examine prospects for the deployment of new nuclear plants in the U.S. during this decade, and to identify obstacles to deployment and actions for resolution. This report, volume one of two, is a summary Report, giving a synopsis of the NTDG evaluations, conclusions and recommendations.

DOE 2002: U.S. Department of Energy. Recommendations for Analyzing Accidents Under the National Environmental Policy Act. Office of NEPA Policy and Compliance. July 2002. http://www.eh.doe.gov/nepa/tools/guidance/analyzingaccidentsjuly2002.pdf: Guidance for preparing accident analyses in DOE EISs and EAs. This guidance addresses NEPA policy and requirements related to accident analyses in NEPA documents, and is targeted primarily to those responsible for preparing NEPA documents, including NEPA Document Managers, NEPA Compliance Officers, and document reviewers. This guidance does not provide detailed technical instructions for analysis of accidents; it presumes that accident analysts have appropriate technical knowledge and skills.

DOE 2004: U.S. Department of Energy, Environment, Safety and Health, Office of NEPA Policy and Compliance. Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements, Second Edition. December 2004. http://www.eh.doe.gov/nepa/tools/guidance/volume2/2-10-greenbook-recommendations.pdf: This document provides recommendations for the Department of Energy‘s (DOE‘s) preparation of environmental assessments and environmental impact statements under the National Environmental Policy Act of 1969 (NEPA). The recommendations should materially aid those responsible for preparing and reviewing NEPA documents to focus on significant environmental issues, adequately analyze environmental impacts, and effectively present the analysis to decisionmakers and the public.

DOE 2005: DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment, October 2005. http://www.ne.doe.gov/np2010/reports/mpr2776Rev0102105.pdf This report assesses the adequacy of infrastructure to support the near-term deployment of new nuclear power plants in the United States. As part of the NP2010 Program, DOE tasked MPR Associates, Inc. to evaluate the infrastructure necessary to support construction of new U.S. Generation III+ (GEN III+) nuclear power plants in the 2010 timeframe. This infrastructure assessment‘s primary objective was to identify any specific infrastructure weaknesses and to recommend appropriate actions and lead times for mitigating potential impacts on GEN III+ plant construction schedules.

DOE 2006: U.S. Department of Energy. Memorandum: Need to Consider Intentional Destructive Acts in NEPA documents. Office of NEPA Policy and Compliance. December 1, 2006. http://eh.doe.gov/nepa/tools/terrorism--interim_nepa_guidance.pdf: Interim guidance on inclusion of intentional destructive acts in NEPA documents.

DOE 2007: U.S. Department of Energy. Yucca Mountain Repository, Licensing. Office of Civilian Radioactive Waste Management. Web page last modified December 2007. http://www.ocrwm.doe.gov/ym_repository/license/index.shtml: Website providing the status of the licensing process for Yucca Mountain Repository. Includes links to fact sheets on licensing.

DOE 2008: DOE 2008: U.S. Department of Energy, Office of Nuclear Energy. Gen IV Nuclear Energy Systems (website). http://www.ne.doe.gov/genIV/neGenIV1.html: This website on Generation IV nuclear energy systems covers, ―what is Generation IV?", DOE nuclear energy strategic goals, and U.S. Generation IV priorities, U.S. accomplishments, and planned activities related to Generation IV reactors. The website links to resources and documents.

DOE 2008: U.S. Department of Energy, Office of Nuclear Energy. New Plant Incentives within the Energy Policy Act of 2005 (EPACT 2005). Website. http://www.ne.doe.gov/energyPolicyAct2005/neEPACT2a.html This website describes new plant incentives within the Energy Policy Act of 2005 (EPACT 2005) including incentives for innovative technologies, a tax credit for production from advanced nuclear power facilities, loan guarantees for up to 80 percent of eligible project costs, numerous research and development programs related to existing and advanced reactors, and provisions for education of future specialists.

DOE 2008: U.S. Department of Energy. Report on Lessons Learned from the NP 2010 Early Site Permit Program, Final Report. Prepared by Energetics Incorporated, March 26, 2008. http://www.ne.doe.gov/pdfFiles/FinalReportonESPLessonsLearned.pdf : This report provides a summary of lessons learned from the demonstration of the licensing process for three Early Site Permit (ESP) applications supported as part of the Department of Energy‘s (DOE) Nuclear Power 2010 (NP 2010) program. DOE competitively selected Dominion Nuclear Energy North Anna, LLC (Dominion); System Energy Resources, Inc. (an Entergy subsidiary); and Exelon Generation Company, LLC (Exelon) in 2002 to demonstrate the ESP process and provided cost-shared support through the NP 2010 program. Dominion pursued an ESP for the North Anna site in Virginia; System Energy Resources, Inc. pursued an ESP for the Grand Gulf site in Mississippi; and Exelon pursued an ESP for the Clinton site in Illinois. After successfully demonstrating the process, the NRC issued an ESP for Clinton on March 17, 2007; Grand Gulf on April 5, 2007; and North Anna on November 27, 2007. In general, these lessons pertain to the effectiveness of the regulatory process, experience related to guidance for developing and reviewing ESP applications, issues involving ESP plant parameters, and suggestions for future ESP applicants.

Dominion Energy et al. 2004: Study of Construction Technologies and Schedules, O&M Staffing and Cost, Decommissioning Costs and Funding Requirements for Advanced Reactor Designs, United States Department of Energy, Volume 1. Prepared by Dominion Energy Bechtel Power Corporation Inc TLG, Inc., and MPR Associates, May 27, 2004. http://www.ne.doe.gov/np2010/reports/1DominionStudy52704.pdf In support of DOE‘s Nuclear Power 2010 program, Dominion Energy in cooperation with its industry partners completed a study of the changes in nuclear plant design and construction and the impact on operational cost, decommissioning, and construction techniques. This study focused on three key areas where additional information was needed to support a future industry decision on nuclear power deployment. Four new reactor designs were selected for this study: The Toshiba and General Electric ABWR, the GE ESBWR, the Westinghouse advanced passive pressurized water reactor (AP1000), and the AECL Advanced CANDU Reactor (ACR-700).

Dominion 2007: Dominion Energy, Inc. North Anna 3, Combined License Application, Part 3: Applicant‘s Environmental Report - Combined License Stage. November 2007. ADAMS accession number ML081220353: This Applicants‘ Environmental Report-Combined License Stage is submitted pursuant to 10 CFR 51.50(c) to provide environmental information supporting the application of Virginia Electric and Power Company, doing business as Dominion Virginia Power (Dominion or DVP), and the Old Dominion Electric Cooperative (ODEC) for a combined construction permit and operating license for a third nuclear unit at the North Anna Power Station (NAPS).

EPA 1984: U.S. Environmental Protection Agency. Policy and Procedures for the Review of Federal Action Impacting the Environment. October 3, 1984. http://www.epa.gov/compliance/resources/policies/nepa/nepa_policies_procedures.pdf: This manual establishes policies and procedures for carrying out the Environmental Protection Agency's (EPA's) responsibilities to review and comment on Federal actions affecting the quality of the environment. EPA has general statutory authority under the National Environmental Policy Act of 1969 and the Council on Environmental Quality's implementing regulations, and has specific authority and responsibility under Section 309 of the Clean Air Act to conduct such reviews, comment in writing, and make those comments available to the public. This manual contains EPA's policies and procedures for carrying out the Environmental Review Process, assigns specific responsibilities, and outlines mechanisms for resolving problems that arise in the Environmental Review Process. It has been updated with the issuance of an errata sheet (EPA 2007).

EPA 1995: U.S. Environmental Protection Agency, Office of Federal Activities. Pollution Prevention - Environmental Impact Reduction Checklists for NEPA/309 Reviewers, January 1995. http://www.epa.gov/compliance/resources/policies/nepa/pollution-prevention-checklist-nepa-pg.pdf : A series of checklists prepared to assist NEPA/309 reviewers in incorporating pollution prevention into each step of the environmental review process, including scoping, mitigation, monitoring, and enforcement.

EPA 1995: U.S. Environmental Protection Agency. AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous sources, 13.4 Wet cooling towers, January 1995. http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s04.pdf: This is a section of a larger reference on emission factors, specific to cooling systems. The Emission Factor and Inventory Group in the U. S. Environmental Protection Agency's (EPA) Office of Air Quality Planning and Standards develops and maintains emission estimating tools. The AP-42 series is the principal means by which emission factors are documented by EPA with process details and supporting reference material.

EPA 1998: U.S. EPA, Final Guidance for Incorporating Environmental Justice Concerns in EPA's NEPA Compliance Analyses, April 1998. http://www.epa.gov/compliance/resources/policies/ej/ej_guidance_nepa_epa0498.pdf: This document serves as a guidance to incorporate environmental justice goals into EPA's preparation of environmental impact statements (EISs) and environmental assessments (EAs) under NEPA.

EPA 1999: U.S. EPA Office of Federal Activities, Final Guidance for Consideration of Environmental Justice in Clean Air Act 309 Reviews, July 1999. http://www.epa.gov/compliance/resources/policies/nepa/enviro_justice_309review.pdf: This document provides guidance on reviewing and commenting on other federal agencies National Environmental Policy Act (NEPA) documents to help ensure that environmental effects on minority communities and low-income communities have been fully analyzed.

EPA 2001: U.S. EPA Office of Water. Technical Development Document for the Final Regulations Addressing Cooling Water Intake Structures for New Facilities. EPA-821-R-01-036. http://www.epa.gov/waterscience/316b/phase1/technical/index.html. On December 18, 2001 EPA established location, design, construction, and capacity standards for cooling water intake structures at new facilities. This document provides background and supporting technical information.

EPA 2002: United States Environmental Protection Agency, Office of Enforcement and Compliance Assurance. EPA's Section 309 Review: The Clean Air Act and NEPA, Quick Reference Brochure. May 2002: This brochure provides an overview of EPA's role in Section 309 review.

EPA 2004: Incidence and Severity of Sediment Contamination in Surface Waters of the United States. National Sediments Quality Survey, Second Edition EPA 823-R-04-007, November 2004 http://www.epa.gov/waterscience/cs/report/2004/nsqs2ed-complete.pdf: This survey describes the accumulation of chemical contaminants in river, lake, ocean, and estuary bottoms and includes a screening-level assessment of the potential for associated adverse effects on human and/or environmental health. The United States Environmental Protection Agency (EPA) prepared this report to Congress in response to requirements set forth in the Water Resources Development Act (WRDA) of 1992. WRDA directed EPA, in consultation with the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Army Corps of Engineers (USACE), to conduct a comprehensive national survey of data regarding the quality of aquatic sediments in the United States.

EPA 2006: Comments to Supplement 1 of the DEIS for ESP at North Anna ESP Site. August 28, 2006. http://www.epa.gov/reg3esd1/nepa/comments/North%20Anna%20ESP%20DEIS.pdf: Letter dated August 28, 2006 from the U.S. Environmental Protection Agency, Region 3, from William Arguto, NEPA team leader to Mr. Jack Cussing of the U.S. Nuclear Regulatory Commission providing EPA review comments in accordance with NEPA, Section 309 of the Clean Air Act and CEQ regulations on the DEIS for ESP at North Anna ESP Site.

EPA 2007: Comments to Final Environmental Impact Statement (FEIS) for an Early Site Permit (ESP) at the North Anna ESP Site –NRUEG 1811, February 2, 2007: Letter from William Arguto, NEPA Team Leader, EPA Region 3, to Mr. Jack Cushing, U.S. NRC, Re: Final Environmental Impact Statement (FEIS) for an Early Site Permit (ESP) at the North Anna ESP Site –NRUEG 1811 (North Anna ESP Project, CEQ No 20060524)

EPA 2007: Vehicle/Equipment Management, Tribal Compliance Assistance Center webpage, updated November 28, 2007. http://www.epa.gov/tribalcompliance/buildandveh/bvvehicledrill.html: This webpage describes vehicle equipment/maintenance activities that could affect the environment and identifies typical wastes generated. It also suggests pollution prevention techniques.

EPA 2007: U.S. Environmental Protection Agency. Uranium Mining Wastes. Web page last updated November 7, 2007. http://www.epa.gov/radiation/tenorm/uranium.html#who_regulates: Overview of Uranium Mining Wastes with Links to Technical Studies.

EPA 2007: Letter from Heinz J. Mueller, Chief NEPA Program Officer, U.S. EPA Region 4 to Chief, Rules, Directives, and Editing Branch, U.S. NRC, Re: Review and Comments on DEIS for Vogtle Electric Generating Plant Site, Issuance of Early Site Permit (ESP) for Construction and Operation of a New Nuclear Power Generating Facility, NUREG 1872, CEQ 20070386, November 28, 2007: EPA comment letter on Vogtle Draft ESP EIS

EPA 2007: Office of Enforcement and Compliance Assurance. Memorandum: Errata for the Policy and Procedures for the Review of Federal Actions Impacting the Environment. From Anne Norton Miller, Director, OFA. July 19, 2007. Provides updates to EPA 1984.

IAEA 2007: International Atomic Energy Agency. Considerations for Waste Minimization at the Design Stage of Nuclear Facilities. Technical Reports Series, No. 460. http://www-pub.iaea.org/MTCD/publications/PDF/trs460_web.pdf: This report identifies and outlines issues for consideration during the design and operation of nuclear facilities to minimize waste generation, facilitate future decommissioning, and optimize management of operational and decommissioning waste and material. It is aimed at the broad range of experts involved in the planning, design, construction, and operation of new nuclear facilities or the modification of existing facilities. The principles discussed are applicable to all types and classes of nuclear facility dealing with radioactive material. While plant designs will continue to mature and evolve, the waste minimization options identified here will remain relevant to all new facilities and can be used as a checklist during the design, licensing, and operational phases of new plants or the modification of existing plants.

FWS undated: U.S. Fish and Wildlife Service. NEPA Reference Handbook (glossary). http://www.fws.gov/r9esnepa/NEPA_HANDBOOK2.pdf: The glossary of this hand book provides a definition of the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity used in this guidance. The purpose of the NEPA Reference Handbook is to provide Fish and Wildlife Service personnel with full texts of various NEPA authorities, selected NEPA-related authorities, and NEPA-related checklists.

L&C 2007: Lewis & Clark Law School. San Luis Obispo Mothers for Peace v. Nuclear Regulatory Comm'n; 449 F.3d 1016 (9th Cir. 2006). Portland, OR. http://www.elawreview.org/summaries/environmental_quality/nepa/san_luis_obispo_mothers_for_pe.html change format of link in sec 6

Najjar et al. 1979: K.F. Najjar, J.J. Shaw, E.E. Adams, G.H. Jirka, and D.R.F. Harleman. An Environmental and Economic Comparison of Cooling System Designs for Steam-Electric Power Plants. Energy Laboratory Report No. MIT-EL-79-037. Department of Civil Engineering, Massachusetts Institute of Technology. Cambridge, MA: This report is part of an interdisciplinary effort by the MIT Energy Laboratory to examine issues of power plant cooling system design and operation under environmental constraints. The selection of waste heat rejection systems for steam-electric power plants involves a trade-off among environmental, energy and water conservation, and economic factors. This study compares four general types of cooling systems on the basis of these factors. The cooling systems chosen for study are: once-through systems including surface canals and submerged multiport diffusers; shallow closed cycle cooling ponds; mechanical and natural draft evaporative cooling towers; and mechanical draft dry towers.

NRC 1976: U.S. Nuclear Regulatory Commission. Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations (Rev. 2). http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/: The purpose of this guide is to aid applicants in preparing environmental reports. Use of the format of this guide will help ensure the completeness of the information provided, will assist the NRC .staff and others in locating the information, and will aid in shortening the time needed for the review process. Conformance with this format, however, is not required. This guide, though old, is referenced frequently in NUREG 1555.

NRC 1977: Regulatory Guide 4.11 Terrestrial Environmental Studies for Nuclear Power Stations, Revision 1, August 1977. ADAMS accession No. 003957041: This regulatory guide, though old, is referred to in NUREG 1555 under discussions of terrestrial ecology. This regulatory guide provides technical information for the design and execution of terrestrial environmental studies for nuclear power stations. The information resulting from the studies, as they relate to ecological aspects of site selection, assessment of terrestrial effects of station construction and operation, and formulation of related monitoring activities, may be appropriate for inclusion in the applicant's environmental report.

NRC 1996: Generic Environmental Impact Statement for License Renewal of Nuclear Plants. NUREG-1437. U.S. Nuclear Regulatory Commission. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/: Generic Environmental Impact Statement for renewing licenses of individual NPPs under 10 CFR Part 51. Objectives are (1) to provide understanding of types and severity of environmental impacts, (2) to identify and assess those impacts that are expected to be generic to license renewal, and (3) to support a rulemaking to define the number and scope of issues that need to be addressed by applicants in plant-by-plant license renewal proceedings.

NRC 2000: U.S. Nuclear Regulatory Commission. NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/: This document provides guidance to the staff in implementing provisions of 10 CFR Part 51, "Environmental Protection Regulations for

Domestic Licensing and Related Regulatory Functions," related to new site/plant applications. It supersedes "Environmental Standard Review Plans for the Environmental Review of Construction Permit Applications for Nuclear Power Plants,"NUREG-0555, issued in 1978. New technical issues—such as environmental justice and severe-accident mitigation design alternatives—and new licensing structures—such as early site permits, combined licenses, and license renewal—have raised the need for new regulatory guidance. Supplement 1 to this document should be used for review of environmental reports related to license renewal.

NRC 2001: U.S. Nuclear Regulatory Commission. Regulating Nuclear Fuel, rev. 1, NUREG/BR-0280. September 2001. Office of Public Affairs. http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0280/br0280r1.pdf: This booklet focuses on the responsibilities of the U.S. Nuclear Regulatory Commission (NRC) in the first part of the fuel cycle—the mining of uranium and its conversion and enrichment into a form that is used in a nuclear power plant to produce electricity.

NRC 2002: Early Site Permit Meeting with Nuclear Energy Institute, Meeting Handouts. ADAMS accession number 004089395: Handouts from slide presentation on ―Use of Bounding Plant Parameters Envelope" by the Nuclear Energy Institute (NEI) Early Site Permit Task Force. Presentation to the U. S. Nuclear Regulatory Commission July 16, 2002.

NRC 2002: U.S. Nuclear Regulatory Commission. Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities, Supplement 1, Regarding the Decommissioning of Nuclear Power Reactors, NUREG-0586. November 2002. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0586/s1/v1/vol1.pdf This Supplement was prepared because of technological advances in decommissioning operations, experience gained by licensees, and changes made to NRC regulations since the 1988 GEIS. This Supplement updates the information provided in the 1988 GEIS. It is intended to be used to evaluate environmental impacts during the decommissioning of nuclear power reactors as residual radioactivity at the site is reduced to levels that allow for termination of the NRC license. This Supplement addresses only the decommissioning of nuclear power reactors licensed by the NRC. It updates the sections of the 1988 GEIS relating to pressurized water reactors, boiling water reactors, and multiple reactor stations. It goes beyond the 1988 GEIS to explicitly consider high-temperature gas-cooled reactors and fast breeder reactors. This | document can be considered a stand-alone document for power reactor facilities such that | readers should not need to refer back to the 1988 GEIS.

NRC 2002: U.S. Nuclear Regulatory Commission. Policy Issue Notation Vote for the Commissioners, from William D. Travers, Executive Director for Operations (SECY-02-0175), September 27, 2002, Referencing: Denial of Petition for Rulemaking to Eliminate Review of Alternative Sites, Alternative Energy Sources and Need for Power in Nuclear Power Reactor Siting and Licensing Reviews (PRM-52-2). http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2002/secy2002-0175/2002-0175scy.html: The purpose of this paper is to obtain Commission approval to: (1) deny a petition for rulemaking to eliminate reviews of alternative sites, alternative energy sources, and need for power in nuclear power reactor siting and licensing reviews; and (2) continue with current staff efforts to develop the technical bases for rulemaking to specifically define the requirements for consideration of alternative sites, which the staff expects would address some of the petitioner's concerns in this area.

NRC 2004: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. NRR REVIEW STANDARD, Processing Applications for Early Site Permits, May 3, 2004. ADAMS accession number 050600127: The goal of an NRC review standard is to ensure that the staff‘s reviews of licensing actions are conducted in an effective, efficient, and consistent manner; and that the reviews result in high-quality and timely products. This review standard describes the process for reviewing an early site permit (ESP) application and provides guidance for completing the steps in the process.

NRC 2004: U.S. Nuclear Regulatory Commission, Office of Public Affairs. Nuclear Power Plant Licensing Process, NUREG/BR-0298, Rev. 2. http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0298/br0298r2.pdf : In order for a commercial nuclear power plant to operate in the United States, it has to obtain a license from the U.S. Nuclear Regulatory Commission (NRC). Among other things, the NRC is responsible for licensing and regulating the operation of nuclear power plants. NRC‘s role is described in this brochure.

NRC 2004: U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation. Review Standard, "Processing Applications for Early Site Permits, RS-002. May 3, 2004: This NRC staff review standard describes the process for reviewing an early site permit (ESP) application and provides guidance for completing the steps in the process. The objective of this review standard is to ensure that staff reviews of applications for early site permits (ESPs) and the associated environmental reports are effective, efficient, and consistent; and that the reviews result in high-quality products.

NRC 2004: Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions, August 24, 2004. http://a257.g.akamaitech.net/7/257/2422/06jun20041800/edocket.access.gpo.gov/2004/pdf/04-19305.pdf: NRC policy statement that the NRC is committed to the general goals of E.O. 12898 and will strive to meet those goals through its normal and traditional NEPA review process. NRC believes that an analysis of disproportionately high and adverse impacts needs to be done as part of the agency‘s NEPA obligations to accurately identify and disclose all significant environmental impacts associated with a proposed action.

NRC 2004b: U.S. Nuclear Regulatory Commission Office of Nuclear Reactor Regulation, Procedural Guidance for Preparing Environmental Assessments and Considering Environmental Issues, LIC-203 (ADAMS# ML033550003), may 24, 2004. http://www.nrc.gov/reactors/operating/licensing/renewal/introduction/introduction-files/lic-203rev1.pdf This office instruction, along with attached guidance documents, provide all staff in the NRC‘s Office of Nuclear Reactor Regulation (NRR) a basic framework for maintaining NRC‘s responsibility to comply with 10 CFR Part 51. This office instruction is intended to: (1) define the responsibilities of the License Renewal and Environmental Impacts Branch (RLEP) to ensure that NRR is consistent in its implementation of NRC regulations and other Federal environmental requirements; (2) define NRR staff responsibilities; and, (3) provide guidance to NRR staff on the procedural requirements for demonstrating compliance with environmental statutes and regulations covering environmental issues for regulated facilities. This guidance includes Environmental Justice Guidance in an appendix (appendix D).

NRC 2005: U.S. Nuclear Regulatory Commission, Office of Public Affairs. Nuclear Power Plant Licensing Process Backgrounder. July 2005. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/licensing-process-bg.pdf: This NRC fact sheet explains the licensing process for nuclear power plants, including a brief overview of combined licenses, early site permits, and design certifications.

NRC 2006: Environmental Impact Statement for an Early Site Permit (ESP) at the North Anna ESP Site: Final Report. NUREG-1811. U.S. Nuclear Regulatory Commission Office of New Reactors. December 2006. Washington, DC. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1811/draft/sr1811.pdf: This environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by Dominion Nuclear North Anna, LLC (Dominion), for an early site permit (ESP). The proposed action requested in Dominion's application is for the NRC to (1) approve a site within the existing North Anna Power Station (NAPS) boundaries as suitable for the construction and operation of one or more new nuclear power generating facilities and (2) issue an ESP for the proposed site located at NAPS. The proposed action does not include any decision or approval to construct or operate one or more units; these are matters that would be considered only upon the filing of applications for a construction permit and an operating license, or an application for a combined license.

NRC 2006: Environmental Impact Statement for an Early Site Permit (ESP) at the Exelon ESP Site- Final Report NUREG-1815. U.S. Nuclear Regulatory Commission Office of New Reactors. Washington, DC. July 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1815/sr1815v1.pdf: This environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by Exelon Generation Company, LLC (Exelon) for an early site permit (ESP). The proposed action requested in Exelon's application is for the NRC to (1) approve a site within the existing Clinton Power Station (CPS) boundaries as suitable for the construction and operation of a new nuclear power generating facility and (2) issue an ESP for the proposed site identified as the Exelon ESP site located adjacent to the CPS. In its application, Exelon proposes a plan for redressing the environmental effects of certain site-preparation and construction activities, i.e., those activities allowed by Title 10 of the Code of Federal Regulations (CFR) 50.10(e)(1), performed by an ESP holder under 10 CFR 52.25. In accordance with the plan, the site would be redressed if the NRC issues the requested ESP (containing the site redress plan), the ESP holder performs these site-preparation and construction activities, the ESP is not referenced in an application for a construction permit or combined operating license, and no alternative use is found for the site. This EIS includes the NRC staff's analysis that considers and weighs the environmental impacts of constructing and operating a new nuclear unit at the Exelon

ESP site or at alternative sites, and mitigation measures available for reducing or avoiding adverse impacts. It also includes the staff's recommendation to the Commission regarding the proposed action.

NRC 2006: Environmental Impact Statement for an Early Site Permit (ESP) at the Grand Gulf ESP Site. NUREG-1817. U.S. Nuclear Regulatory Commission Office of New Reactors. Washington, DC. April 2006. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1817: This environmental impact statement (EIS) has been prepared in response to an application submitted to the U.S. Nuclear Regulatory Commission (NRC) by System Energy Resources, Inc. (SERI) for an early site permit (ESP). The proposed action requested in SERI‘s application is for the NRC to (1) approve a site within the existing Grand Gulf Nuclear Station boundaries as suitable for the construction and operation of a new nuclear power generating facility, and (2) issue an ESP for the proposed site identified as the Grand Gulf ESP site co-located with the existing Grand Gulf Nuclear Station. This EIS includes the NRC staff‘s analysis that considers and weighs the environmental impacts of constructing and operating up to two new nuclear units at the Grand Gulf ESP site or at alternative sites, and mitigation measures available for reducing or avoiding adverse impact. It also includes the staff‘s recommendation to the Commission regarding the proposed action.

NRC 2006: U.S. Nuclear Regulatory Commission. Tritium, Radiation Protection Limits, and Drinking Water Standards. Office of Public Affairs. July 2006. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/tritium-radiation-fs.pdf: The U.S. Nuclear Regulatory Commission (NRC) has recently evaluated several instances of abnormal releases of liquid tritium from several nuclear power plants, which resulted in groundwater contamination. This fact sheet explains what the NRC doing about the tritium leaks and spills at nuclear power plants, discusses risks, and explains radiation protection limits and drinking water standards.

NRC 2006: U.S. Nuclear Regulatory Commission. Backgrounder on Emergency Preparedness at Nuclear Power Plants. Office of Public Affairs, January 2006. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/emerg-plan-prep-nuc-power-bg.html: This fact sheet discusses several aspects of emergency preparedness at nuclear power plants including federal oversight, emergency planning zones, emergency classification, and protective actions.

NRC 2007: U.S. Nuclear Regulatory Commission. Regulatory Guide 1.206 Combined License Applications for Nuclear Power Plants (LWR Edition). June 20, 2007: The issuance of combined licenses (COLs) for nuclear power plants is governed by Title 10, Part 52, ―Licenses, Certifications, and Approvals for Nuclear Power Plants,” of the Code of Federal Regulations (10 CFR Part 52), which specifies the information to be included in a COL application. This regulatory guide applies to applications for COLs for nuclear power plants. Although prepared to provide guidance to COL applicants, use of this guide‘s format and content descriptions by design certification and early site permit (ESP) applicants will facilitate subsequent integration with COL applications.

NRC 2007: Nuclear Regulatory Commission. Power Reactors. February 12, 2007. http://www.nrc.gov/reactors/power.html This website describes pressurized water and boiling water reactors. It provides links to diagrams and locations of licensed reactors in the U.S.

NRC 2007: Final Rule: Limited Work Authorizations for Nuclear Power Plants, 10 CFR Parts 2, 50, 51, 52, and 100, 72 Federal Register 57416 (October 9, 2007). http://edocket.access.gpo.gov/2007/pdf/E7-19312.pdf : In this final rule, the Nuclear Regulatory Commission amended its regulations applicable to limited work authorizations (LWAs), which allow certain construction activities on production and utilization facilities to commence before a construction permit or combined license is issued. This final rule modifies the scope of activities that are considered construction for which a construction permit, combined license, or LWA is necessary, specifies the scope of construction activities that may be performed under an LWA, and changes the review and approval process for LWA requests. An LWA application must include a safety analysis; an environmental report; and a plan for redress of the site to address the placement of piles and ensure removal of the foundation, which are the only activities that may be accomplished under an LWA, in the event that construction is terminated by the applicant or denied by NRC (10 CFR 50.10 (d)). NRC will complete a Final EIS on the proposal before issuing the LWA (10 CFR 50.10 (e)).

NRC 2007: U.S. Nuclear Regulatory Commission. NUREG 0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/ch2/ The Standard Review Plan (SRP) provides guidance to US Nuclear Regulatory Commission (NRC) staff in performing safety reviews of construction permit (CP) or operating license (OL) applications (including requests for amendments) under 10 CFR Part 50 and early site permit (ESP), design certification (DC), combined license (COL), standard design approval (SDA), or manufacturing license (ML) applications under 10 CFR Part 52 (including requests for amendments). The principal purpose of the SRP is to assure the quality and uniformity of staff safety reviews. It is also the intent of this plan to make information about regulatory matters widely available and to improve communication between the NRC, interested members of the public, and the nuclear power industry, thereby increasing understanding of the NRC's review process.

NRC 2007. U.S. Nuclear Regulatory Commission. Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (NUREG-0800). Division of Inspection and Support Programs, Office of Nuclear Reactor Regulation. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/cover/: This Standard Review Plan (SRP) provides guidance to US Nuclear Regulatory Commission (NRC) staff in performing safety reviews of construction permit (CP) or operating license (OL) applications (including requests for amendments) under 10 CFR Part 50 and early site permit (ESP), design certification (DC), combined license (COL), standard design approval (SDA), or manufacturing license (ML) applications under 10 CFR Part 52 (including requests for amendments). The principal purpose of the SRP is to assure the quality and uniformity of staff safety reviews. It is also the intent of this plan to make information about regulatory matters widely available and to improve communication between the NRC, interested members of the public, and the nuclear power industry, thereby increasing understanding of the NRC's review process.

NRC 2007. U.S. Nuclear Regulatory Commission. Glossary. http://www.nrc.gov/reading-rm/basic-ref/glossary.html#T: One of NRC's basic references about nuclear energy. Web-based glossary of terms.

NRC 2007: U.S. Nuclear Regulatory Commission. Memorandum and Order: In the Matter of System Energy Resources, Inc. (early site permit for Grand Gulf ESP Site). http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2007/2007-10cli.html#n_4: Except for within jurisdiction of 9th Circuit, EISs do not have to include analysis of impacts of terrorist attack on spent fuel storage.

NRC 2007: U.S. Nuclear Regulatory Commission. Memorandum and Order: In the Matter of AmerGen Energy Company, LLC (License Renewal for Oyster Creek Nuclear Generating Station) http://www.nrc.gov/reading-rm/doc-collections/commission/orders/2007/2007-08cli.pdf : Affirms the Board's rejection of New Jersey's NEPA-terrorism contention.

NRC 2007: U.S. Nuclear Regulatory Commission. Stages of the Fuel Cycle. Web page updated February 13, 2007. http://www.nrc.gov/materials/fuel-cycle-fac/stages-fuel-cycle.html: Website listing the stages of the nuclear fuel cycle with links to more information on mining (extracting from ore) and milling, conversion to uranium hexafluoride, enrichment, fuel fabrication into uranium oxide, interim storage, and high-level waste.

NRC 2007: U.S. Nuclear Regulatory Commission. High Level Waste Disposal. Web page updated February 13, 2007. http://www.nrc.gov/waste/hlw-disposal.html: This webpage provides an explanation of high level waste disposal regulation and licensing activities.

NRC 2007: U.S. Nuclear Regulatory Commission, NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants, Updated Sections. July 2007. http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/updates.html: See NRC 2000. NUREG 1555, Standard Review Plan for the Environmental Reviews for Nuclear Power Plants.

NRC 2007: U.S. Nuclear Regulatory Commission. Memorandum and Order in the Matter of Dominion Nuclear North Anna, LLC (Early Site Permit for North Anna ESP Site), Docket No. 52-008-ESP. November 20, 2007: This NRC memorandum and order approves the issuance of an early site permit (ESP) for the North Anna ESP site in Louisa County, Virginia. This Memorandum and Order examines the differing views of the majority and dissent on those two issues. The majority of the Board approved issuance of the North Anna ESP, while the dissenting judge would have denied the ESP due to insufficiencies in the NRC Staff's and Dominion's examinations of alternative sites and alternative design features related to water conservation.

NRC 2008: U.S. Nuclear Regulatory Commission. Fact Sheet on Uranium Enrichment. January 2008. Office of Public Affairs. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/enrichment.html: Throughout nuclear industry, uranium is enriched by one of two methods: gaseous diffusion or gas centrifuge. A third method – laser enrichment – has been proposed for use in the United States. All three methods are described in this fact sheet.

NRC 2008: U.S. Nuclear Regulatory Commission. Expected New Nuclear Power Plant Applications. Updated April 23, 2008. http://www.nrc.gov/reactors/new-licensing/new-licensing-files/expected-new-rx-applications.pdf: List of expected new power plant applications. Includes the name of the company applying for a license, the proposed design (if known) and the proposed location. The list also provides the status of the application acceptance review.

NRC 2008: U.S. Nuclear Regulatory Commission. Fact sheet: Decommissioning Nuclear Power Plants. Office of Public Affairs. January 2008. http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/decommissioning.pdf: When a power company decides to close its nuclear power plant permanently, the facility must be decommissioned by safely removing it from service and reducing residual radioactivity to a level that permits release of the property and termination of the operating license. This fact sheet describes Nuclear Regulatory Commission rules governing nuclear power plant decommissioning, which involves cleanup of radioactively contaminated plant systems and structures and removal of the radioactive fuel.

Pace University 2000: Power Scorecard: Water Quality Issues of Electricity Production (webpage). http://www.powerscorecard.org/issue_detail.cfm?issue_id=6 : Webpage describing on-and off-Site land impacts of generating electricity.

PG&E 2005: Pacific Gas and Electric. Delta Distribution Planning Area Capacity Increase Substation Project, Proponent's Environmental Assessment, August 2005. http://www.cpuc.ca.gov/Environment/info/aspen/deltasub/pea/16_corona_and_induced_currents.pdf: Chapter of an Environmental Assessment that discusses corona and induced current effects associated with operation of high-voltage electric transmission lines. These effects include audible noise; radio, television, and computer monitor interference; gaseous effluents; shock potential; and fuel ignition. Because these effects are common to all transmission lines, they are discussed as generally applicable.

Swanson 2002: S. Swanson. Resource Notes Number 58: Indicators of Hydrologic Alteration. U.S. Bureau of Land Management. September 9, 2002. http://www.blm.gov/nstc/resourcenotes/respdf/RN58.pdf: Short explanation of methods to analyze hydrological alteration. Provides a table of indicators of hydrological alteration, hydrologic parameters, and ecosystem influences.

TVA 2005: Tennessee Valley Authority, Final Environmental Impact Statement 500-Kv Transmission Line in Middle Tennessee, July 2005.

http://www.tva.gov/environment/reports/tn500k/chapter4.pdf: This FEIS was prepared by The Tennessee Valley Authority for a proposal to construct and operate a 500-kV transmission line in northern Middle Tennessee. Environmental consequences discussed in this FEIS served as resource for understanding transmission line impacts.

U.S. Court of Appeals 2006: United States Court of Appeals for the Seventh Circuit, No. 06-1442, *Environmental Law and Policy Center v. United States Nuclear Regulatory Commission,* 470 F.3d 676 (7th Cir. 2006). Appeal from the U.S. Nuclear Regulatory Commission. No. CLI-05-29. http://caselaw.lp.findlaw.com/data2/circs/7th/061442p.pdf: The U.S. Court of Appeals for the Seventh Circuit decided that consideration of energy efficiency, among other alternatives, was not required in the alternatives analysis in this case.

Wisconsin Public Service Commission 2004: Environmental Impacts of Transmission Lines, July 2004. http://psc.wi.gov/thelibrary/publications/electric/electric10.pdf : This overview reviews the environmental issues and concerns raised by the construction of electric transmission facilities. The first part provides a general summary of the methods to measure and identify environmental impacts. The second part is a directory of specific environmental issues and techniques to minimize or mitigate the impacts.

APPENDICES

A. Required Government Approvals or Permits
B. New Nuclear Power Plant Design Certification Status
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Appendix A. Required Government Approvals or Permits

Prior to construction and operation of a new reactor, applicants are required to hold certain federal, state, and local environmental permits, as well as meet applicable federal and state statutory requirements. NRC's Environmental Standard Review Plan, NUREG-1555 directs NRC staff to review required permits and approvals to determine the status, identify environmental concerns, and evaluate potential administrative problems that could delay or prevent agency authorization.

The table below lists the environmentally related authorizations, permits, and certifications potentially required by federal, state, regional, local, and affected Native American tribal agencies related to the construction and operation of a potential new nuclear unit. State, tribal, and local requirements are included in general terms and would have to be determined on a site-specific basis. This list was generated based on the requirements enumerated in the three recent ESP EISs and also the environmental report submitted by the applicant for the COL for the North Anna site.

Federal Agency Authorizations, Permits, or Certifications

Agency	Authority	Requirement	Activity Covered
EPA	Clean Water Act	Clean Water Act, Section 402 (Following states do not yet have program authorization; therefore, EPA is the permitting authority: AK, DC, ID, MA, NH, NM, Indian Lands, and Puerto Rico). Clean Water Act prohibits the discharge of pollutants (Section 301) unless authorized (Section 402).	NPDES permits control the discharge of pollutants, including compliance with Section 316(b), water quality-based effluent limitations, compliance with water quality certification, and stormwater (discharge of storm water associated with construction activities and, after construction, discharge of storm water associated with industrial activity (40 CFR 122.26(b)(10(14)(vii))).
NRC	Atomic Energy Act of 1954, 10 CFR 51	Environmental report	Site approval for a nuclear power station separate from an application for a standard design certification or COL
NRC	Atomic Energy Act (AEA), 10 CFR 51, 10 CFR 52.17	EIS	Environmental effects of construction and operation of a reactor
NRC	10 CFR Part 50	Construction permit	Construction of a new NPP
NRC	10 CFR 52, Subpart A	Early site permit	Approval of the site for one or more nuclear power facilities, and approval of limited construction per 10 CFR 50.10(e)(1)
NRC	10 CFR 52, Subpart C	Combined license	NRC requirements and procedures applicable to issuance of combined licenses for nuclear power facilities

Agency	Authority	Requirement	Activity Covered
NRC	10 CFR 30	Byproduct materials license	NRC license to possess special nuclear materials
NRC	10 CFR 70	Special nuclear materials license	NRC license to possess nuclear fuel
Federal Aviation Administration	49 USC 1501; 14 CFR 77.13	Construction notice	Notice of erection of structures (>200 feet) potentially impacting air navigation.
U.S. Coast Guard	14 USC 81, 83, 85, 633/49 USC 1655(b)	Siting navigation markers	Authorization to protect river navigation from hazards connected with temporary construction activities in the river.
U.S. Army Corps of Engineers	33 CFR 209	Dredge and fill discharge permit	Permit for discharge of dredged spoils
U.S. Army Corps of Engineers	Clean Water Act, 33 USC 1251, 1344; 40 CFR 123	Section 404 permit	Aquatic resource alteration permit (wetland filling, stream alteration), disturbing or crossing wetland areas or navigable waters
U.S. Army Corps of Engineers	Rivers and Harbors Act, Section 10; 33 USC 403	Section 10 permit	Impacts to navigable waters of the United States
U.S. Army Corps of Engineers	Marine Protection, Research, and Sanctuaries Act, 33 USC 1401, 1413	Section 103 permit	Permit for the transportation of dredged material for the purpose of dumping it into ocean waters
U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries	Endangered Species Act, Section 7	Consultation	Impacts to endangered or threatened species and habitat
U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries	Endangered Species Act, Section 10	Incidental take permit	Project-related mortality and modification of critical habitat of federally listed threatened or endangered species
U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries	Marine Mammal Protection Act	Exemptions from take prohibition	Any project-related take of any marine mammal
U.S. Fish and Wildlife Service	Migratory Bird Treaty Act, 16 USC 703	Consultation	Consultation concerning potential impacts to migratory birds

State Authority under Federal Statutes (including delegated or authorized authority)

Program	Authority	Activity
Waste Management	Resource Conservation and Recovery Act	Storage and transportation of hazardous materials
Air Quality	Clean Air Act, Title V	Permit for operation of air emission sources
	Clean Air Act	Construction and operation of minor air emission sources
Water Resources	Clean Water Act, Section 401	State water quality certification of activities for which a federal permit is sought and that may discharge pollutants
	Clean Water Act, Section 402 (not approved in AK, DC, ID, MA, NH, NM, and all territories except Virgin Islands)	Waste water regulations for NPDES permits, including compliance with Section 316(b), water quality-based effluent limitations, water quality certification, and stormwater permits.
	Clean Water Act, Section 404 state administration (to date, only MI and NJ have assumed the program) (40 CFR 123)	Permit for the discharge of dredge or fill material into waters of the U.S. (and any other waters the state/tribe has identified).
	Clean Water Act, State Programmatic General Permit (Section 404)	Permit for the discharge of dredge or fill material into waters of the U.S. (and any other waters the state/tribe has identified). This is a general permit issued by the USACE for specified waters within the state/tribe. The state permit is accepted as complying with the federal Clean Water Act 404 permit requirements. This is overseen by USACE.
Cultural and Historical Resources	National Historic Preservation Act, Section 106	Confirmation that site and transmission line right-of-way are not considered historic preservation areas under 36 CFR Part 800, Consultation with State Historic Preservation Officer as required.
Coastal Zone Management	Coastal Zone Management Act, Section 307	Certification that action is consistent with the state's coastal zone management program.

Activities That May Require State Authorizations, Permits, or Certifications

Program	Activities
Miscellaneous / Construction	• Approval for construction of new generating facility • Underground storage tank regulations • Storage tanks containing petroleum products • Certificate that the present and future public convenience and necessity require or will require the operation of such equipment for facility • Special equipment permissions such as use of lift crane, dome lighting mast • Construction/ modification of surface water discharge structures • Construction of transmission lines crossing waterways or state highways • Construction of waste treatment facilities • Construction of temporary sewage treatment unit • Operation of temporary sewage treatment unit
Ecology	• Ecological monitoring programs • Consultation/coordination with state wildlife agency on state-listed species

Program	Activities
Waste Management	• Hazardous waste management regulations • Non-hazardous solid waste management regulations and criteria • Transportation of sanitary waste water (sanitary waste water hauling permit) • Disposal of sludge (sludge disposal operating permit) • Transportation of non-hazardous waste water or sludge • Disposal of waste from additional waste streams (supplemental waste streams permit) • Recovery and recycling of refrigerants Refrigerant (Recovery/ Recycling Equipment Certifications)
Air Quality	• Annual re-certification of air emission sources (registration) • Permit for the construction and/or operation of air emissions equipment • State regulations for the prevention of significant deterioration of air quality • Open burning of petroleum products for backup generators (open burning permit)
Water	• General permit to discharge storm water during operations • Permit to withdraw surface water (unless otherwise regulated by state) • General permit to discharge storm water from site during construction • Termination of coverage under the general permit for storm water discharge from construction site activities • Termination of coverage under the general permit for storm water discharge associated with operational site activities General Permit for storm water discharges from industrial activity • Termination of coverage under the general permit for storm water discharge associated with operations activities • Surface water and groundwater use and protection regulations • Water quality criteria for intrastate, interstate, and coastal waters • Regulations for the certification of municipal and domestic waste water facility operators • Withdrawal of water from a public surface water source • Treatment of waste water discharge • Disposal or discharge of dredge or fill materials into waters of the state/tribe or impacts to these waters
Historic and Cultural Resources	• Determinations/approvals related to historic preservation areas

County Authorizations, Permits, or Certifications (Examples)

- Zoning permit for construction of the plant
- County dust control permit

Appendix B. New Nuclear Power Plant Design Certification Status

Reactor	Manufacturer	Design Certification Status
ABWR	General Electric Nuclear Energy	Certified May 1997
System 80+	Westinghouse	Certified May 1997
AP600	Westinghouse	Certified December 1999
AP1000	Westinghouse	Certified February 2006 Applicant submitted application to amend the design in July 2007 to address several items instead of deferring them to COL applications, voluntarily comply with the intent of the proposed aircraft impact assessment rule, and modify the pressurizer design. NRC review is expected to be complete in 2009, with rulemaking is tentatively scheduled for completion in 2010.
ESBWR	General Electric	Under Active Review Applicant submitted application on August 24, 2005 and it was accepted by NRC on December 1, 2005. Certification process is expected to continue through 2010.
EPR	Framatome (Areva NP)	Under Active Review Application submitted to NRC on December 11, 2007. NRC is reviewing the completeness of the application. If it is accepted for review, certification process would be expected to continue through 2011.
PBMR	Pebble Bed Modular Reactor (PBMR) Pty. Limited	Under Active Review Applicant notified the NRC on February 18, 2004, of intent to apply for design certification in the near future and requested discussions to plan the scope and content of the pre-application review. NRC has held several public meetings with PBMR. Pre-application information has continued to come in to NRC from PBMR, who expects to submit a design certification application in late 2009.
US-APWR	Mitsubishi Heavy Industries (MHI)	Under Active Review Applicant submitted design certification application for the U.S.-specific version of its Advanced Pressurized Water Reactor on December 31, 2007. NRC is reviewing the completeness of the application. If it is accepted for review, certification process would be expected to continue through 2011.
SWR 1000	Framatome (Areva NP)	Inactive Framatome informed EPA of intent to pursue design certification in 2002, followed by several meetings with NRC staff. In January 2005, NRC noted in their semiannual status report that there had been no interactions in the past six months between Framatome and the NRC staff regarding the SWR 1000 reactor design, and that it would be omitted from future updates unless new interaction occurs.

Reactor	Manufacturer	Design Certification Status
IRIS	Westinghouse	Inactive Design certification application is expected in 2010. Applicant has submitted topical reports related to the planned test programs and plans to submit additional reports in support of pre-application interactions. The IRIS design is sometimes mentioned in the context of a grid-appropriate reactor under the Global Nuclear Energy Partnership.
Toshiba 4S	Toshiba	Inactive On February 2, 2005, NRC staff met with municipal representatives from Galena, Alaska regarding the city's plans to build a Toshiba 4S reactor. Toshiba began pre-application discussions with NRC staff in October 2007 and expects to submit a design approval application in 2009.

Source: NRC Office of Public Affairs, Backgrounder: New Nuclear Plant Designs. March 2008.
http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/new-nuc-plant-des-bg.pdf

Appendix C. Design Profile/Technical Summary of Reactor System Designs

An overview of boiling water reactors, pressurized water reactors, and other reactor designs was provided in Section 2 of this guidance, ―Description of Typical Nuclear Power Plants." The specific designs falling into these categories are described in this appendix. Because the level of detail publicly available describing the various reactor designs varies widely, the level of detail in this document varies as well.

Boiling Water Reactors

Advanced Boiling Water Reactor (ABWR)

The ABWR design was certified by the U.S. Nuclear Regulatory Commission (NRC) in May 1997. It uses a single-cycle, forced circulation reactor with a rated power of 1,300 megawatts electric (MWe). The design incorporates features of the BWR designs in Europe, Japan, and the U.S., and uses improved electronics, computer, turbine, and fuel technology. The design is expected to increase plant availability, operating capacity, safety, and reliability. Improvements include the use of internal recirculation pumps, control rod drives that can be controlled by a screw mechanism rather than a step process, microprocessor-based digital control and logic systems, and digital safety systems. The design also includes safety enhancements such as protection against overpressurizing the containment, passive core debris flooding capability, an independent water makeup system, three emergency diesels, and a combustion turbine as an alternate power source (NRC 2007b).

Typical size: The ABWR generates 1,360 MWe (Dominion and Bechtel 2002). Each unit requires 23.7 acres for the plant area, 15 acres for cooling towers, and 8 acres for the ultimate heat sink (Dominion and Bechtel 2002, Part 1, Section 1).

Construction material of the plant: The reactor vessel is contained in a reinforced concrete containment vessel with a steel liner, located in a reinforced concrete reactor building (GE 2000, Chapter 1).

Fuel description: The ABWR core contains 872 uranium oxide fuel assemblies in one of five configurations, selected based on a plant‘s operating strategy; generally there would be about 92 fuel rods per assembly (GE 2000, Chapter 1).

Economic and Simplified Boiling Water Reactor (ESBWR)

Design certification for the ESBWR is currently under review by the NRC. The ESBWR is a 1,390 MWe natural circulation BWR that incorporates passive safety features. This design is based on its predecessor, the 670 MWe simplified BWR, and also utilizes features of the certified ABWR. Natural circulation was enhanced in the ESBWR by using a taller vessel, a shorter core, and by reducing the flow restrictions. The ESBWR design utilizes the isolation condenser system for high-pressure water level control and decay heat removal during isolated conditions. After the automatic depressurization system operates, low-pressure water level control is provided by the gravity-driven cooling system. Containment cooling is provided by the passive containment cooling system (NRC 2007b).

Typical size: The ESBWR generates 1,550 MWe (Hinds and Maslak 2006).

Construction material of the plant: The ESBWR reactor building is constructed of reinforced concrete, and the reactor containment vessel is reinforced concrete with a steel liner (GE 2006, Chapter 1).

Fuel description: The ESBWR core contains 1,132 fuel assemblies, each with 78 full length and 14 part length rods of uranium dioxide (GE 2006, Chapter 6).

Siedewasser Reactor-1000 (SWR-1000)

Pre-certification of the SWR-1000 design by the NRC was initially pursued, but has now been deferred. The SWR-1000 is a medium-capacity BWR, with a design that entails the partial replacement of active safety systems with passive safety features. The passive safety systems utilize basic laws of physics, such as gravity, enabling these systems to function without electrical power supply or actuation by powered instrumentation and control systems. The new concepts provide passive protection of the core without operator intervention for up to three days while minimizing the costs and complexities associated with today's active safety systems concepts (Areva 2003).

Typical size: The gross electrical output of the SWR-1000 is 1,290 MWe (Areva 2003).

Construction material of the plant: The SWR-1000 reactor is housed in a steel-reinforced and steel-lined concrete containment (Areva 2003).

Fuel description: The reactor core contains 664 fuel assemblies (Areva 2003).

Pressurized Water Reactors

Advanced Passive AP600 and AP1000

The AP600 design was certified by the NRC in December 1999. This is a 600 MWe advanced PWR that incorporates passive safety systems and simplified system designs. The passive systems use natural driving forces without active pumps, diesels, and other support systems after actuation. Use of redundant, non-safety-related active equipment and systems minimizes unnecessary use of safety-related systems (NRC 2007b). The AP600 has been bid overseas but has never been built. Westinghouse has deemphasized the AP600 in favor of the larger, though potentially less expensive (on a kilowatt basis) AP1000 design (DOE undated).

NRC certified the AP1000 design in February 2006. NRC is currently reviewing an application to amend the design certification. The AP1000 is a larger version of the previously approved AP600 design, which can provide approximately 1000 MWe. It is similar to the AP600 design but uses a longer reactor vessel to accommodate longer fuel, and also includes larger steam generators and a larger pressurizer (NRC 2007b).

Typical size: 600 MWe (AP600) or 1,117 to 1,154 MWe (AP1000, depends on the secondary coolant) would be generated. The plant site is estimated to require 9.6 acres, with cooling towers requiring an additional 15 acres (Dominion and Bechtel 2002, Part 1, Section 2).

Construction material: The reactor is housed in a freestanding steel containment structure, which is further contained in a reinforced concrete shield building (Westinghouse 2007).

Fuel description: The AP600 uses a 145-fuel-assembly core (Cummins et al. 2003). The AP1000 uses a 157-fuel-assembly core (Westinghouse 2007). Both can also accommodate mixed oxide (MOX) fuel. (MOX is a mixture of uranium and plutonium that results from the U.S.'s re-processing of excess nuclear weapons grade plutonium into a form that can be used as commercial power plant fuel).

European Power Reactor (EPR)

NRC is currently reviewing the EPR's design certification application, which was submitted on December 11, 2007. The EPR is a large four-loop PWR with design output of approximately 1,600 MWe. Design features include four 100 percent capacity safety systems, double-walled containment, and a ―core catcher" for containment and cooling of core materials in the case of a severe accident resulting in reactor vessel failure. The design does not rely on passive safety features (NRC 2007b).

Typical size: 1,600 MWe are generated. One U.S. EPR will occupy only about 150 acres – including the switchyard, administrative buildings, parking, and cooling tower structures. An additional 49 acres will be used during construction (Areva 2007). Needs for controlling radiological exposure at the site boundary and securing the perimeter could increase this area, based on site-specific conditions.

Construction material of the plant: The EPR reactor is contained within a steel-lined concrete containment building, which is enclosed by a reinforced concrete shield building (Framatome 2005, Section 1.2).

Fuel description: 241 fuel assemblies, with 265 fuel rods per assembly containing a total of 1,338 pounds of uranium oxide per assembly (Framatome 2005, Section 2.1). The fuel rods are composed of a stack of enriched uranium dioxide sintered pellets or MOX, with or without burnable absorber (gadolinium), contained in a hermetically sealed cladding tube made of M5™ alloy (Areva 2007).

International Reactor Innovative and Secure (IRIS)

The IRIS is in pre-application review with the NRC. It is a pressurized light water cooled, medium-power (335 MWe) reactor that has been under development for several years by an international consortium. IRIS is a PWR that utilizes an integral reactor coolant system layout.

The IRIS reactor vessel houses not only the nuclear fuel and control rods, but also all the major reactor coolant systems components including pumps, steam generators, pressurizer, and neutron reflector. The IRIS integral vessel is larger than a traditional PWR pressure vessel, but the size of the IRIS containment is a fraction of the size of corresponding loop reactors (NRC 2007b).

Typical size: The IRIS unit would generate 335 MWe (Carelli et al. 2004). The designers propose a twin-unit plant configuration that would cover approximately 14 acres (Carelli 2003), not including allowance for controlling radiological exposure at the site boundary, securing the perimeter, parking, and administration.

Construction material: The current IRIS layout features a spherical steel containment vessel that would be almost half below ground (Carelli et al. 2004).

Fuel description: The IRIS core contains 89 fuel assemblies, each with 264 fuel rods (Carelli et al. 2004). It can be configured to use sintered uranium oxide or MOX fuel (Westinghouse 2001).

System 80+

The System 80+ reactor design was certified in May 1997. This standard plant design uses a 1,300 MWe PWR. The System 80+ design has safety systems that provide emergency core cooling, feedwater, and decay heat removal. The new design also has a safety depressurization system for the reactor, a combustion turbine as an alternate AC power source, and an in-containment refueling water storage tank to enhance the safety and reliability of the reactor system (NRC 2007b). Although it has formed the basis of South Korea‘s nuclear power program, Westinghouse is not currently promoting this design (NEI 2007).

U.S. Advanced Pressurized Water Reactor (US-APWR)

NRC received the design certification application for the US-APWR on December 31, 2007. The Mitsubishi Heavy Industry US-APWR design is an evolutionary 1,700 MWe PWR currently being licensed and built in Japan. The design includes high-performance steam generators, a neutron reflector around the core to increase fuel economy, redundant core cooling systems and refueling water storage inside the containment building, and fully digital instrumentation and control systems (NRC 2007b).

Typical size: The US-APWR will generate 1,700 MWe (Mitsubishi 2007, Table 1.3-1).

Construction material: The containment vessel is a prestressed, post-tensioned concrete structure with a cylindrical wall, hemispherical dome, and a flat, reinforced concrete foundation slab (Mitsubishi 2007, Chapter 1.1.2).

Fuel description: The 257 fuel assemblies in the US-APWR core each contain 264 rods of sintered uranium dioxide pellets slightly enriched up to 5 percent and/or gadolinia-uranium dioxide pellets blended with maximum 10 percent content of Gd_2O_3 (Mitsubishi 2007, Chapter 1.2.1.5.1.1).

Advanced Canada Deuterium Uranium (CANDU) Reactors ACR-700 and ACR-1000

The advanced CANDU reactor (ACR) designated ACR-700 is in pre-application review by NRC as of January 2008; the ACR-1000 has not been submitted for pre-certification consideration. The ACR-700 is a 700 MWe light-water-cooled reactor with two steam generators and four heat transport pumps. Similar to previous CANDU designs, the ACR-700 uses heavy water as a moderator in the reactor, while light water is used as the coolant. This is the first reactor in the CANDU series to have a negative void reactivity coefficient. The ACR-700 also uses slightly enriched uranium fuel, computer-controlled operation, and on-power fueling. The ACR-1000 is a larger version of the same reactor.

Typical size: The ACR-700 generates 731 MWe, and the ACR-1000 generates 1,200 MWe.

Construction material: The ACR reactor is housed in a steel-lined, pre-stressed concrete building structure (CANTEACH 2008).

Fuel description: The ACR reactors use an ACR version of the CANFLEX fuel system, containing slightly enriched uranium in horizontal fuel channels (CANTEACH 2008).

Other Reactor Designs

Reactor designs have been developed that use systems other than water to cool the reactor core and transmit heat energy to an electric turbine. Several of these are described in the following paragraphs.

Pebble Bed Modular Reactor (PBMR)

NRC expects to receive a design certification application for the PBMR in late 2009. The PBMR is a high-temperature gas-cooled reactor consisting of a steel pressure vessel that holds about 450,000 fuel spheres. The PBMR system is cooled with helium, which transfers heat to the power conversion system and converts it into electricity through a turbine. The plant consists of a module building with the reactor pressure vessel and the power conversion unit. The vertical steel pressure vessel is 6.2 m in diameter and about 27 m high. It is lined with a 1-m (39-inch) thick layer of graphite bricks, which serves as an outer reflector and a passive heat transfer medium. The graphite brick lining is drilled with vertical holes to house the control elements (PBMR 2008).

Typical size: A PBMR plant can be configured in a variety of sizes by combining one or more stand-alone modules. Each PBMR module has an electrical output of approximately 160 MWe; therefore, for an 8-module plant, the gross output would be about 1,280 MWe (Dominion and Bechtel 2002, Part 1, Section 5). For an 8-module plant, the plant area would require about 7.5 acres, and cooling towers would require about 18 acres. A separate ultimate heat sink area is not required with this design (Dominion and Bechtel 2002, Part 1, Section 5).

Fuel description: The PBMR uses particles of low enriched uranium dioxide coated with four layers. The first layer deposited on the kernels is porous carbon, which accommodates any mechanical deformation that the uranium dioxide kernel may undergo during the lifetime of the fuel as well as gaseous fission products diffusing out of the kernel. This is followed by a thin coating of pyrolytic carbon (a very dense form of heat -treated carbon), a layer of silicon carbide (a strong refractory material), and another layer of pyrolytic carbon. The pyrolytic carbon and silicon carbide layers provide an impenetrable barrier designed to contain the fuel and radioactive fission products resulting from nuclear reactions in the kernel. Some 15,000 of these coated particles, now about a millimeter in diameter, are then mixed with graphite powder and a phenolic resin and pressed into the shape of 50-mm diameter balls. A 5-mm thick layer of pure carbon is then added to form a “non-fuel” zone, and the resulting spheres are then sintered and annealed to make them hard and durable. Finally, the spherical fuel “pebbles” are machined to a uniform diameter of 60 mm, about the size of a tennis ball. Each fuel pebble contains 9 g of uranium. The total uranium in one fuel load is 4.1 metric tons and the total mass of a fuel pebble 210 g. During normal operation, the PBMR core contains a load of 456,000 fuel pebbles. A graphite column is located in the centre of the core and the fuel pebbles in the annulus around it. Graphite is used in nuclear applications because of its structural characteristics and its ability to slow down neutrons to the speed required for the nuclear reaction to take place. This geometry limits the peak temperature in the fuel following a loss of coolant. In order to have a self-sustaining or “chain” reaction, the uranium in the PBMR pebbles is enriched to about nine percent uranium-235. The reactor is continuously replenished with fresh or re-useable fuel from the top, while used fuel is removed from the bottom. After each pass through the reactor core the fuel pebbles are measured to determine the amount of fissionable material left. If the pebble still contains a usable amount of the fissile material, it is returned to the reactor at the top for a further cycle. Each cycle takes about six months. Each pebble passes through the reactor about six times and lasts about three years before it is spent, which means that a reactor will use 12 total fuel loads in its design lifetime. The extent to which the enriched uranium is consumed during the lifetime of a fuel pebble (called the extent of “burn-up”) is much greater in the PBMR than in conventional power reactors. There is therefore minimal fissionable material that could be extracted from spent PBMR fuel. This, coupled with the level of technology and cost required to break down the barriers surrounding the spent fuel particles, protects the PBMR fuel against the possibility of nuclear proliferation or other covert use (PBMR 2008).

Toshiba Super Safe, Small and Simple (4S)

On February 2, 2005, the NRC staff met with the City Manager and Vice Mayor of Galena, Alaska to discuss and answer questions on the city‘s plans to build a Toshiba 4S reactor to provide its electricity. To date, Toshiba has not contacted the NRC regarding possible licensing of the 4S. The Toshiba 4S reactor design has an output of about 10 MWe. The reactor has a compact core design, with steel-clad metal-alloy fuel. The core design does not require refueling over the 30-year lifetime of the plant. A three-loop configuration is used: primary system (sodium-cooled), an intermediate sodium loop between the radioactive primary system and the steam generators, and the water loop used to generate steam for the turbine. The basic layout is a “pool” configuration, with the pumps and intermediate heat exchanger inside the primary vessel (NRC 2007b).

Typical size and construction material of the plant: The 4S would generate about 10 MWe.

Fuel description: Potential fuels are uranium or uranium-plutonium alloys. When uranium is the likely fuel in the U.S., present plans call for 19.9 percent fuel enrichment. This high level of enrichment is one reason the reactor could be able to operate for extended periods without refueling (DOE undated).

Gas Turbine – Modular Helium Reactor (GT-MHR)

The GT-MHR is in pre-application review by the NRC. It is a modular integrated direct-cycle nuclear power facility. Key design characteristics of the gas-cooled MHR are the use of helium coolant, graphite moderator, and refractory coated particle fuel. The helium coolant is inert and remains single phase under all conditions; the graphite moderator has high strength and stability to high temperatures; and the refractory coated particle fuel retains fission products to high temperatures (LaBar 2002). The high temperature helium coolant directly drives a gas turbine coupled to an electric generator. The efficiency of the system is about 48 percent. This is about 50 percent more efficient than today's first generation reactors. A typical GT-MHR module, rated at 600 MWt, yields a net output of about 286 MWe (Dominion and Bechtel 2002, Part 1, Section 3).

Typical size: The GT-MHR generates 286 MWe (Dominion and Bechtel 2002). The plant area requires 44 acres, the cooling towers require 15 acres, and the ultimate heat sink requires 8 acres (Dominion and Bechtel 2002, Part 1, Section 3).

Construction material of the plant: The reactor and power conversion vessels are interconnected with a short cross-vessel and are located in a below-grade concrete silo (LaBar 2002).

Fuel description: The GT-MHR refractory coated particle fuel, identified as tri-isotropic (TRISO)-coated particle fuel, consists of a spherical kernel of fissile or fertile material, as appropriate for the application, encapsulated in multiple coating layers. The multiple coating layers form a miniature, highly corrosion-resistant pressure vessel and an essentially impermeable barrier to the release of gaseous and metallic fission products (LaBar 2002).The reactor can be fueled with uranium or plutonium (Dominion and Bechtel 2002, Part 1, Section 3).

Overview of Generation-IV Concepts

Based on eight far-ranging technology goals, Generation IV nuclear energy systems are aimed at achieving nuclear energy‘s potential worldwide. The objective is a new generation of nuclear energy systems that advance nuclear safety, address nuclear nonproliferation and physical protection issues, are competitively priced, and minimize waste and optimize natural resource utilization (DOE 2008).

Five of the six technology concepts identified in the Generation IV International Forum‘s *Technology Roadmap* are being pursued at varying levels of effort in the U.S., based on their technology status and potential to meet program and national goals.

Two are thermal neutron spectrum systems with coolants and temperatures that enable hydrogen or electricity production with high efficiency:

- very-high-temperature reactor (VHTR)
- supercritical-water-cooled reactor (SCWR)

Three are fast neutron spectrum systems that will enable more effective management of actinides through recycling of most components in the discharged fuel:

- gas-cooled fast reactor (GFR), which parallels the PBMR and original GT-MHR designs but would instead be a "fast" or breeder reactor (DOE undated – EIA website).
- lead-cooled fast reactor (LFR)
- sodium-cooled fast reactor (SFR), elements of which are incorporated into the 4S design described above.

The U.S. is not currently researching the molten salt reactor (MSR) (DOE 2008).

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Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see [Privacy and Security Notice]) may not be available at the external link.

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Appendix D. Environmental Attributes of the Nuclear Power Plant Designs

The anticipated waste streams and water requirements for each power plant design are described here. An overview of boiling water reactors, pressurized water reactors, and other reactor designs was provided in Section 2 of this guidance, ―Description of Typical Nuclear Power Plants.” Specific designs falling into these categories are described in Appendix C.

The level of detail publicly available describing the various reactor designs varies widely. Similarly, the information available for waste volumes and emissions associated with a particular design also varies and, in addition, depends to some extent on plant-specific factors. The International Atomic Energy Agency (IAEA) stated that the amount of waste material generated depends on the design of the reactor system, the nuclear fuel used, and how the plant is operated (IAEA 2007, Section 2.2.2.2). The amount and nature of radioactive waste generated is affected by the reactor system and nuclear fuel used; the materials comprising the reactor vessel, its internal structures, and the equipment in contact with the coolant; the coolant‘s chemical regime; the quality and nature of reactor system additives; and the fuel cladding material (IAEA 2007, Section 2.2.2.2). The volume of waste for final disposal is determined by the waste minimization processes and plant‘s operational procedures.

The widely varying nature of the information available for each reactor type precludes any meaningful side-by-side comparison of emissions or waste stream types and volumes.

Boiling Water Reactors

Advanced Boiling Water Reactor (ABWR)

Anticipated waste streams: GE (2000) stated that the total radioactive waste volume for the ABWR would be less that 21 m^3/year (742 ft^3/year) and also stated that the annual releases to the environment from the ABWR radioactive waste systems would result in human exposures that are several orders of magnitude below the NRC-established limits in 10 CFR Part 20; review of the estimated annual doses for the ABWR in the ABWR Design Control Document (Certrec 2007, Chapter 11) are consistent with this statement.

- Radiological air emissions from an ABWR are estimated to consist of 2.7 x 10^6 MBq/year (see footnote[11]) (73 Ci/year) of tritium, 3.4 x 10^5 MBq/year (9.2 Ci/year) of carbon-14, 2.5 x 10^5 MBq/year (6.8 Ci/year) of argon-41, 1.9 x 10^8 MBq/year (5,100 Ci/year) of krypton and xenon isotopes, 3.8 x 10^5 MBq/year (1,000 Ci/year) of iodines, and approximately 8.9 x 10^3 MBq/year (0.24 Ci/year) of other radionuclides (Certrec 2007). The significant gaseous wastes discharged to the Offgas System during normal plant operation are radiolytic hydrogen and oxygen, main condenser air inleakage, and radioactive isotopes of krypton, xenon, nitrogen, and oxygen (Certrec 2007).
- An ABWR unit is estimated to discharge liquid radioactive waste totaling 3.46 x 10^4 MBq/year (0.934 Ci/year), not including tritium. Tritium release is expected to total 2.22 x 10^6 MBq/year (59.9 Ci/year) (Certrec 2007).

[11] MBq = megabecquerel = 1,000,000 becquerels (Bq). 3.7 x 10^{10} Bq = 1 Ci. 1 MBq = 2.7 x 10^{-5} Ci.

- An ABWR unit is expected to generate about 427 m^3/year of solid radioactive waste, which would be compacted to a volume of 165 m^3/year before being shipped for offsite disposal. The estimated activity shipped is estimated to be about 2.5 x 10^7 MBq/year (680 Ci/year) (Certrec 2007).

Water requirements and necessary cooling systems: The largest water use in the plant is for condenser cooling. However, estimating requirements for cooling water is difficult because the amount of cooling water needed depends on the design of the system, the site environmental requirements, and EPA limits on water use and maximum temperature rise (Dominion and Bechtel 2002, Part 1, Section 1). The reactor building cooling water flow rate is listed as 1,200 m^3/hour per loop (GE 2000), equivalent to about 5,300 gallons/minute.

Economic and Simplified Boiling Water Reactor (ESBWR)

Anticipated waste streams (from GE Hitachi 2007, Chapter 11):

- Radiological air emissions from an ESBWR are estimated to consist of 2.8 x 10^6 MBq/year (76 Ci/year) of tritium, 3.54 x 10^5 MBq/year (9.56 Ci/year) of carbon-14, 2.85 x 10^2 MBq/year (7.70 x 10^{-3} Ci/year) of argon-41, 1.53 x 10^8 MBq/year (4,130 Ci/year) of krypton and xenon isotopes, 2.9 x 10^5 MBq/year (7.8 Ci/year) of iodines, and approximately 4.62 x 10^3 MBq/year (0.125 Ci/year) of other radionuclides.
- An ESBWR unit is estimated to discharge liquid radioactive waste totaling 3.62 x 10^3 MBq/year (0.0977 Ci/year), not including tritium. Tritium release is expected to total 5.18 x 10^5 MBq/year (14.0 Ci/year).
- An ESBWR unit is expected to generate about 474 m^3/year of solid radioactive waste, which would be compacted to a volume of 448 m^3/year before being shipped for offsite disposal, and also about 0.4 m^3/ year of mixed waste.

Water requirements and necessary cooling systems: The normal flow rate for each of two loops of reactor cooling water is 1,250 m^3/hour, or 5,500 gallons/minute per loop. The normal flow rate for each of two loops of plant service water is 9,085 m^3/hour, or 40,000 gallons/minute per loop (GE 2006). Site-specific cooling towers would be incorporated into the design (GE 2006).

SWR-1000

Anticipated waste streams: No information was identified.

Water requirements and necessary cooling systems: No information was identified.

Pressurized Water Reactors

AP600 and AP1000

Anticipated waste streams:

- Radiological air emissions from an AP1000 are estimated to consist of 1.3 x 10^7 MBq/year (350 Ci/year) of tritium, 2.7 x 10^5 MBq/year (7.3 Ci/year) of carbon-14, 1.3 x 10^6 MBq/year (34 Ci/year) of argon-41, 4.1 x 10^7 MBq/year (1,100 Ci/year) of krypton and xenon isotopes, 1.9 x 10^4 MBq/year (0.52 Ci/year) of iodines, and approximately 1.7 x 10^3 MBq/year (0.047 Ci/year) of other radionuclides (Westinghouse 2005). Non-radioactive air emissions could include heat and water vapor releases from cooling system; carbon monoxide, particulates, sulfur oxides, nitrogen oxides, and hydrocarbons from infrequent use of diesel generators and auxiliary power; and carbon dioxide emissions associated with that portion of the nuclear fuel cycle attributable to a given plant (NRC 2007).
- An AP1000 unit is estimated to discharge liquid radioactive waste totaling 9,490 MBq/year (0.25623 Ci/year), not including tritium. Tritium release is expected to total 3.74 x 10^7 MBq/year (1,010 Ci/year) (Westinghouse 2005, Chapter 11).
- An AP1000 unit is expected to generate from 5,759 to 11,000 ft^3/year of solid radioactive waste, which would be compacted to a volume of 1,964 to 5,717 ft^3/year before being shipped for offsite disposal. The estimated activity shipped includes 6.52 x 10^7 to 1.19 x 10^9 MBq/year (1,760 to 32,010 Ci/year) of primary wastes and 1.62 x 10^5 to 6.15 x 10^7 MBq/year (4.38 to 1,660 Ci/year) of secondary wastes (Westinghouse 2005, Chapter 11).

Water requirements and necessary cooling systems: The reactor coolant system consists of two heat transfer circuits, with each circuit containing one steam generator, two reactor coolant pumps, and a single hot leg and two cold legs for circulating coolant between the reactor and the steam generators. The system also includes a pressurizer, interconnecting piping, and the valves and instrumentation necessary for operational control and the actuation of safeguards (Cummins et al. 2003). The reactor vessel water flow rate for both loops is 194,000 gallons per minute for the AP600 and 300,000 gallons per minute for the AP1000 (Cummins et al. 2003). Service water cooling is via a natural draft cooling tower with a site-specific configuration (Westinghouse 2005). Dominion and Bechtel (2002) stated ―Circulating water requirements can vary greatly depending on site-specific conditions and limitations. The AP1000 requires no more or no less circulating water than any other similarly sized plant. A very rough estimate is that the required flow rate is somewhere between 450,000 to 750,000 gallons per minute. If the plant uses once-through direct cooling, the required flow rate will generally be less, but it can also vary significantly depending on environmental temperature rise limitations. Makeup for a circulating water system that uses a cooling tower can be estimated at up to 4 percent of the circulating water flow rate. Generally, no makeup is required for a direct cooling application." NRC (2007) estimated total surface water withdrawal of 129 cubic feet per second (cfs) for the 2 proposed AP1000 units at that site, or approximately 64.5 cfs (29,000 gallons per minute) per unit.

European Power Reactor (EPR)

Anticipated waste streams and emissions:

- High-level radioactive waste consists of the spent fuel rods. Low-level radioactive waste includes clothing, hand tools, water purifier resins, and (upon decommissioning) the materials of which the reactor itself is built. An EPR unit is expected to generate 7,933 ft^3/year of solid radioactive waste. The estimated maximum activity is 2.49 x 10^9 MBq (67,300 Ci) (Areva 2007b, Chapter 11).

- Hydrogen, oxygen, and nitrogen are released to the air, along with radioactive gases (xenon, krypton) that are released to the air after holding for adequate time to decay to acceptable level of radioactivity (Framatome 2005). Radiological air emissions from an EPR are estimated to consist of 6.7 x 10^6 MBq/year (180 Ci/year) of tritium, 2.7 x 10^5 MBq/year (7.3 Ci/year) of carbon-14, 1.3 x 10^6 MBq/year (34 Ci/year) of argon-41, 1.7737 x 10^9 MBq/year (47,889 Ci/year) of krypton and xenon isotopes, 1,500 MBq/year (0.0408 Ci/year) of iodines, and approximately 47 MBq/year (0.00126 Ci/year) of other radionuclides (Areva 2007b, Chapter 11).

- During EPR operation, waste water and liquid wastes are produced by system drains, leakage, flushing, and other processes. The EPR has a liquid radioactive waste processing and storage system that performs the collection, short-term storage, processing, and cleaning of the waste streams produced by letdown, drainage, purge, venting, or leakage from systems in the controlled area. The liquid waste processing system is designed to performs activity retention and limits releases to the environment; selectively collects and segregates liquid effluents produced by the reactor coolant and auxiliary systems, reactor cavity and spent fuel pool, as well as all potentially contaminated liquids produced in the plant such as floor drains, laundry, and decontamination wastes (Framatome 2005). An EPR unit is estimated to discharge liquid radioactive waste totaling 7,000 MBq/year (0.19 Ci/year), not including tritium. Tritium release is expected to total 5.93 x 10^7 MBq/year (1,660 Ci/year) (Areva 2007b, Chapter 11).

Water requirements and cooling systems: The EPR‘s reactor cooling system is a conventional four-loop design. The reactor coolant flows through the hot leg pipes to the steam generators and is pumped back to the reactor pressure vessel via the cold leg pipes. A pressurizer is connected to one hot leg and two cold legs. The reactor cooling water flow rate is 124,730 gallons per minute per loop in a closed, pressurized system (Areva 2007a). The circulating water cooling system can be provided by mechanical draft, natural draft, or dry cooling towers, based on site-specific requirements with consideration given to footprint, thermal efficiency, and cost. Depending on the cooling system selected, water requirements will range from less than one million gallons/day (1,700 gallons per minute) for dry towers, to as much as 45 million gallons/day (78,000 gallons per minute) for an all-wet system like mechanical or natural-draft cooling towers (Areva 2007a).

International Reactor Innovative and Secure (IRIS)

Anticipated waste streams: Detailed calculations of routine emissions and dose estimates have not been performed for the IRIS, but Westinghouse believes they can be bounded by those estimated for the AP600, adjusting for the power size (Dominion and Bechtel 2002, Part 1, Section 4.7). For a three-unit system, the upper bounds on IRIS waste generation were estimated to be 2,600 ft^3/year of solid radioactive waste; less than 5,900 and less than 2.6×10^7 MBq/year (less than 0.16 and less than 690 Ci/year) of non-tritium and tritium liquid radioactive wastes, respectively; and 3.7×10^8, 1.7×10^4, 2,600, and less than 3.7×10^6 MBq/year (10,000, 0.45, 0.07, and less than 100 Ci/year) air emissions of noble gases, iodines, other radionuclides, and tritium, respectively (Dominion and Bechtel 2002, Part 1, Section 4.7).

Water requirements and necessary cooling systems: The IRIS primary coolant flow rate is 4,700 kg/second (Carelli 2003), equivalent to 74,500 gallons per minute. The condensation and service water cooling system design would be site-specific. No information was identified on total feedwater volume requirements. Makeup water for the service water cooling system is approximately 250 gallons per minute for a single unit (Dominion and Bechtel 2002, Part 1, Section 4.6).

System 80+

Anticipated waste streams: No information was identified.

Water requirements and necessary cooling systems: No information was identified.

US-APWR

Anticipated waste streams:

- Radiological air emissions from a US-APWR are estimated to consist of 6.7×10^6 MBq/year (180 Ci/year) of tritium, 2.7×10^5 MBq/year (7.3 Ci/year) of carbon-14, 1.3×10^6 MBq/year (34 Ci/year) of argon-41, 6.2×10^7 MBq/year (1,672 Ci/year) of krypton and xenon isotopes, 2,500 MBq/year (0.0682 Ci/year) of iodines, and approximately 1,900 MBq/year (0.051 Ci/year) of other radionuclides (Mitsubishi 2007, Chapter 11).
- A US-APWR unit is estimated to discharge liquid radioactive waste totaling 9,600 MBq/year (0.26 Ci/year), not including tritium. Tritium release is expected to total 5.9×10^7 MBq/year (1,600 Ci/year) (Mitsubishi 2007, Chapter 11).
- A US-APWR unit is expected to ship 15,278 ft^3/year of solid radioactive waste (Mitsubishi 2007).

Water requirements and necessary cooling systems: The reactor coolant system will pump 112,000 gallons per minute per loop, and the residual heat removal pump will handle a flow of 3,000 gallons per minute (Mitsubishi 2007, Chapter 5).

Advanced CANDU Reactors ACR-700 and ACR-1000

Anticipated waste streams: No information was available.

Water requirements and necessary cooling systems: No information was available.

Other Reactor Designs

Reactor designs have been developed that use systems other than water to cool the reactor core and transmit heat energy to an electric turbine. Several of these are described in the following paragraphs.

Pebble Bed Modular Reactor (PBMR)

Anticipated waste streams:

- Routine gaseous emissions are estimated not to exceed 1.5 x 10^7 MBq/year (400 Ci/yr) for an 8-module plant, with tritium releases estimated below 6.4 x 10^7 MBq/year (1,720 Ci/yr (Dominion and Bechtel 2002, Part 1, Section 5).
- The anticipated average annual quantity of solid waste by a single module is approximately 10 m^3 of compacted waste at an overall compaction ration of approximately 5:1. A PBMR module is anticipated to produce 25 to 100 drums of solid operational waste, 8 drums of filters, and 3 drums of unserviceable activated and contaminated structures, systems, and components waste per annum (Exelon 2001).
- A PBMR module is expected to generate (Exelon 2001):
  - 480 m^3/yr of liquid waste from the decontamination facility and laboratory (up to 6 x 10^7 Bq/m^3 (1.6 mCi/m^3) specific activity).
  - 500 m^3/yr liquid waste from laundry (up to 6 x 10^7 Bq/m^3 (1.6 mCi/m^3) specific activity)
  - 365 m^3/year possibly active liquid waste from building floor drain sumps (up to 6 x 10^6 Bq/m^3 (0.16 mCi/m^3) specific activity)
  - 100 m^3/year possibly active liquid waste from showers and washrooms (up to 6 x 10^6 (0.16 mCi/m^3) Bq/m^3 specific activity)

Water requirements and necessary cooling systems: Helium is used as the coolant and energy transfer medium, to drive a closed cycle gas turbine and generator system. To remove the heat generated by the nuclear reaction, helium coolant enters the reactor vessel at a temperature of about 500 ºC (932 ºF) and very high pressure. The gas moves down between the hot fuel spheres, after which it leaves the bottom of the vessel having been heated to a temperature of about 900 ºC (1,652 ºF). The hot gas then enters the turbine which is mechanically connected to the generator on one side and the gas compressors on the other side. The coolant transfers some of its heat and then leaves the turbine at about 500 ºC (932 ºF) and somewhat reduced pressure, after which it is cooled, recompressed, reheated, and returned to the reactor vessel (PBMR 2008).

For an 8-module plant using mechanical draft cooling towers, cooling water flow is estimated at 260,991 gallons per minute and makeup flow is estimated at 15,659. Once-through cooling flow is estimated at 724,974 gallons per minute for an 8-module plant. The PBMR has no need for containment heat removal systems. Maximum raw water use is estimated at 23,775 gallons per day (Dominion and Bechtel 2002, Part 1, Section 5.6).

Toshiba Super Safe, Small and Simple (4S)

Anticipated waste streams: Unlike conventional reactors, the 4S concept is for the sealed reactor to be delivered at the site, installed with the generator system, operated for the prescribed design life, removed, and replaced with the sealed assembly intact. Thus, during operation, there would be no emissions (other than steam), no release of radioactivity, and minimum chance of radiation exposure when the reactor assembly is buried. Operation of the 4S would generate small volumes of nonradioactive solid waste (trash) and potentially small volumes of nonradioactive hazardous waste (Chaney et al. 2004, Executive Summary and Section 5.4).

Water requirements and necessary cooling systems: Both the primary and secondary cooling loops contain liquid sodium as the coolant; there is no water requirement.

Gas Turbine – Modular Helium Reactor (GT-MHR)

Anticipated waste streams: No information was available.

Water requirements and necessary cooling systems: Cooling water use is limited to the makeup and blowdown requirements for a 300 MW heat rejection cooling tower, plus minor heat loads associated with the routine process operations of the plant; no specific flow rates are available (Dominion and Bechtel 2002, Part 1, Section 3.6).

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Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see [Privacy and Security Notice]) may not be available at the external link.

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Appendix E. Review of Known Environmental Contamination

Regulations and Guidance Related to Reporting of Environmental Contamination

Appendix E. Review of Known Environmental Contamination

- Regulations and Guidance Related to Reporting of Environmental Contamination
- Methods of Review
- Major Accidents
- Other Incidents of Known Environmental Contamination

Documentation of environmental contamination from U.S. nuclear power plants is required by federal regulation. The License Event Report System (10 CFR 50.73) requires the holder of an operating license or a combined license for a nuclear power plant to submit a Licensee Event Report for numerous types of events within 60 days after the discovery of the event. Reportable events include any airborne radioactive release that, when averaged over a time period of 1 hour, resulted in airborne radionuclide concentrations in an unrestricted area that exceeded 20 times applicable concentration limits and any liquid effluent release that, when averaged over a time period of 1 hour, exceeded 20 times the applicable concentrations at the point of entry into the receiving waters for all radionuclides except tritium and dissolved noble gases. Applicable concentration limits for specific radionuclides are listed in Appendix B to the regulation.

NRC's immediate notification requirements for operating nuclear power reactors (10 CFR 50.72) specify conditions in which nuclear power reactor licensees shall notify the NRC Operations Center via the Emergency Notification System. Among other conditions, the Emergency Notification System is to be used for ―Any event or situation, related to the health and safety of the public or onsite personnel, or protection of the environment, for which a news release is planned or notification to other government agencies has been or will be made. Such an event may include an onsite fatality or inadvertent release of radioactively contaminated materials."

NUREG 1022, ―Event Reporting Guidelines 10 CFR 50.72 and 50.73", is structured to assist licensees in complying with the reporting requirements. The guidance provides generic examples of radioactive release situations that require reporting and explains administrative requirements.

NRC also requires licensees to report plant discharges and the results of environmental monitoring around their plants to ensure that potential impacts are detected and reviewed. ―In annual reports, licensees identify the amount of liquid and airborne radioactive effluents discharged from plants and the associated doses. Licensees also must report environmental radioactivity levels around their plants annually. These reports, available to the public, cover sampling from thermoluminescent dosimeters; airborne radioiodine and particulate samplers; samples of surface, groundwater, and drinking water and downstream shoreline sediment from existing or potential recreational facilities; and samples of ingestion sources such as milk, fish, invertebrates, and broad leaf vegetation" (NRC 2002). Licensee Event Reports are required when effluent releases exceed those described under the 10 CFR 50.73 requirements explained above.

While 10 CFR 50.72 and 73 specify how environmental contamination events are to be reported by licensees to NRC, Section 208 of the *Energy Reorganization Act* of 1974 (Public Law 93-438), specifies how NRC must report to Congress. Section 208 of the Act defines an ―abnormal occurrence" as an unscheduled incident or event that the NRC determines to be significant from the standpoint of public health or safety. The criteria for event types that shall be considered abnormal events differ by type of licensee and are outlined in Appendix A of NUREG 0090 (NRC 2001-2007). For commercial nuclear power plant licensees, abnormal occurrences would include ―personnel error or procedural deficiencies that result in loss of plant capability to perform essential safety functions so that a release of radioactive materials, which could result in exceeding the dose limits of 10 CFR Part 100 or 5 times the dose limits of 10 CFR Part 50, Appendix A, GDC 19, could occur from a postulated transient or accident (e.g., loss of emergency core cooling system, loss of control rod system)." The *Federal Reports Elimination and Sunset Act* of 1995 (Public Law 104-66) requires that the NRC must report abnormal occurrences to Congress annually. These reports are documented in the annual NRC staff publication, NUREG 0090, Report to Congress on Abnormal Occurrences. Since the Chernobyl accident, the NRC has reported 48 events involving nuclear power reactors to the U.S. Congress as abnormal events (Greens/European Free Alliance 2007, Section 7.3.1), but not all abnormal occurrences involve release of radioactive materials.

Environmental contamination from nuclear power plants is also tracked by the International Atomic Energy Agency (IAEA). The U.S. and 30 other participating countries voluntarily report nuclear incidents, including nuclear power plant incidents to the IAEA. These events are reported on a scale of 1 to 7, in which a rating of 3 indicates very minor external release of radioactivity and a rating of 7 indicates wide-spread, long-term environmental consequences (such as the Chernobyl accident). Releases from commercial plants in other countries can be relevant to operation of U.S. plants since the same or similar nuclear reactor designs and related plant systems may be marketed and operated worldwide.

Methods of Review

Only events from commercial nuclear power reactors were included in this review. Not all NRC and IAEA reports were available for review or readily searchable for environmental contamination events. Therefore, a general Internet search was required to find documented events. Information sources are described in the following sections to indicate the limitations of this review and areas for further investigation.

Event Notification Reports and Licensee Event Reports

Event notification reports (short-term reports to NRC of conditions or events related to facilities regulated by NRC, usually under 10 CFR 50.72) were not searched. These reports are available on the NRC website (http://www.nrc.gov/reading-rm/doc-collections/event-status/event/) for the period January 1999 through January 2008. Reports are presented by date, nearly daily, for this period. A search function was not available.

Licensee Event Reports required under 10 CFR 50.73 were not found on the NRC website. Two examples of radioactive release events requiring a Licensee Event Report under 10 CFR 50.73

are shown below (NRC 2000, Section 3.2.9). No documentation of actual events was found, though these types of events would be highly relevant to this review.

- Example 1: Unmonitored Release of Contaminated Steam through Auxiliary Boiler Atmospheric Vent: An unmonitored release of contaminated steam resulted from a combination of a tube leak, improper venting of an auxiliary boiler system, and inadequate procedures. This combination resulted in a release path from a liquid waste concentrator to the atmosphere via the auxiliary boiler system steam drum vent. Because of rain at the site, the steam release to the atmosphere was condensed and deposited onto plant buildings and yard areas. This contamination was washed via a storm drain into a lake. The release was later confirmed to be 0.000026 microcuries per milliliter (µCi/mL) of cesium-137 at the point of entry into the receiving water. A Licensee Event Report is required as a liquid radioactive material release because the unmonitored release exceeded 20 times the applicable concentrations specified in Table 2, Column 2 of Appendix B to 10 CFR Part 20, averaged over 1 hour at the site boundary.

- Example 2: Unplanned Gaseous Release: During routine scheduled maintenance on a pressure-actuated valve in the gaseous waste system, an unplanned radioactive release to the environment was detected by a main stack high radiation alarm. The release occurred when an isolation valve, required to be closed on the station tag out sheet, was inadvertently left open. This allowed radioactive gas from the waste gas decay tank to escape through a pressure gage connection that had been opened to vent the system. Operator error was the root cause of this release, with ambiguous valve tag numbers as a contributing factor. The concentration in the unrestricted area, averaged over 1 hour, was estimated by the licensee to be 0.00001 µCi/mL of krypton-85 and 0.000005 µCi/mL of xenon-133. The event was reportable via a Licensee Event Report because the sum of the ratios of the concentration of each airborne radionuclide in the restricted area when averaged over a period of 1 hour, to its respective concentration specified in Table 2, Column 1 of Appendix B to 10 CFR Part 20, exceeds 20 [NRC 2000, Section 3.2.9].

NRC Reports to Congress on Abnormal Occurrences

NUREG 0090 Volumes 22 (FY 1999) through 25 (FY 2003), 27 (FY 2004), and 29 (FY 2006) were located for this review. During fiscal years 1999, 2001, 2004, and 2006, no events at U.S. nuclear power plants were significant enough to be reported as abnormal occurrences.

Two events occurring at nuclear power plants in 2000 and in 2002 were reported as abnormal occurrences, one resulting in environmental contamination. A steam generator tube failure at Indian Point Unit 2 in Buchanan, New York, occurred on February 15, 2000, which resulted in a minor release to the environment. This event is described in detail in Section 4.0 of this review.

In 2002, a performance deficiency resulting in reactor vessel head degradation at Davis-Besse Nuclear Power Station in Oak Harbor, Ohio, was reported as an abnormal occurrence. This degradation increased the risk of a loss of coolant accident at the reactor and therefore received media attention and is the basis for ongoing follow-up by NRC. Because no release was involved, this event is not included in the review.

Two events in 2004 and one event in 2006 did not meet the criteria for abnormal occurrences, but were included in the reports to Congress as ―Other Events of Interest.” The 2004 events included licensee record accountability discrepancies at two nuclear power plants, and loss of offsite power at another nuclear power plant; none resulted in environmental contamination.

In the 2006 report, ground water contamination caused by undetected leakage of radioactive water was reported as an ―Other Event of Interest." Several instances of unintended releases of radioactive liquids were identified at multiple plants in 2005 and 2006 and these also are described in Section 4.0 of this review (NRC 2000-2007).

IAEA Incident Reporting System

The IAEA and the Nuclear Energy Agency of the Organization for Economic Cooperation and Development (OECD/NEA) run an Incident Reporting System through which participating countries exchange experience to improve the safety of nuclear power. Access to IAEA's Incident Reporting System database is restricted to IAEA staff, Incident Reporting System national coordinators, nuclear power plants, utilities, and technical and scientific support organizations (IAEA 2004a). The system was set up in 1980 and contains approximately 3,000 records (Greens/European Free Alliance 2007, Section 7.2). These data were not searched for this review.

Even with access to the system, a comprehensive review of international events would not be possible. The IAEA and the OECD/NEA expressed concern that, worldwide, experience related to nuclear power plant operations was not being adequately shared through the Incident Reporting System. Both agencies are concerned by the lack of reporting coverage of significant events and by the substantial decrease in the overall reporting rate (IAEA 2004b). It is widely expected that hundreds of significant events take place annually in every major nuclear country, with many events insufficiently documented or not documented at all (Greens/European Free Alliance 2007, Section 9.1). ―In the United Kingdom, for example, incident reporting has become extremely restrictive in the few years following the 9/11 terrorist attacks, with the Nuclear Security Regulations 2003 rendering it an offence for any person to provide information on nuclear sites and/or activities that could assist the planning and/or implementation of a malicious act" (Greens/European Free Alliance 2007, Section 9.2).

IAEA Safety Reviews 2001-2006

IAEA Nuclear Safety Reviews are published annually. Reports are available for 2001 through 2006 on the IAEA website. According to these reports, there were no events at any nuclear power plant in 2002, 2005, or 2006 that resulted in a release of radioactivity that would cause harm to the environment. The 2003 report (IAEA 2004b) included an incident that occurred in April 2003 at the Paks nuclear power plant in Hungary, which is described in Section 4.0 of this review. The report for 2004 stated that environmental issues from events occurring in the Republic of Korea and the U.S. suggest the need for added vigilance in monitoring all possible plant effluents; however details were not provided in the report (IAEA 2005, Annex 1).

Internet-Published Lists

Publicly available lists and histories of nuclear power plant incidents and accidents provide selective examples; none claim to be comprehensive. Redundancy among these lists indicated significant events were covered for this review. These lists included the U.S. Environmental Protection Agency‘s Nuclear Event/RadNet timeline (EPA 2008), NRC‘s NUREG 1437 section on accidents, IAEA reporting scale example events, and the Uranium Information Center‘s list of serious reactor accidents. Though lists of nuclear power plant events are extensive, most described safety issues (close calls) or occupational exposures, but relatively few described environmental contamination.

Major Accidents

Chernobyl

The Chernobyl disaster was the worst nuclear accident in history. The incident is rated as a 7 on the IAEA international nuclear event scale, the highest rating, indicating a major accident with widespread health and environmental impacts. On April 26, 1986, a reactivity (power increase) accident occurred at Unit 4 of the nuclear power station at Chernobyl, Ukraine, in the former Soviet Union. The accident occurred when a safety test went wrong. The test was initiated to see how long spinning turbines would continue to power the pumps that keep cooling water flowing over the fuel after power is shut down (AECL 1991). The failed test led to a power surge, an explosion, and fires that lasted 10 days (Chernobyl Forum 2005). The accident destroyed the reactor and released massive amounts of radioactivity into the environment.

–The Chernobyl accident caused many severe radiation effects almost immediately. Among the approximately 600 workers present on the site at the time of the accident, 2 died within hours of the reactor explosion and 134 received high radiation doses and suffered from acute radiation sickness. Of these, 28 workers died in the first 4 months after the accident..... The Chernobyl accident also resulted in widespread contamination in areas of Belarus, the Russian Federation, and Ukraine inhabited by millions of residents” (NRC 2006). About 4,000 thyroid cancer cases have been detected among children who drank milk contaminated with radioactive iodine. Most were treated, but nine died of thyroid cancer (NRC 2006). An international expert group, including IAEA and the World Health Organization, predicts that –among the 600,000 persons receiving more significant exposures (liquidators working in 1986-1987, evacuees, and residents of the most contaminated areas), the possible increase in cancer mortality due to this radiation exposure might be up to a few percent. This might eventually represent up to 4,000 fatal cancers” (Chernobyl Forum 2005).

<u>Chernobyl Design Faults</u>

–U.S. reactors have different plant designs, broader shutdown margins, robust containment structures, and operational controls to protect them against the combination of lapses that led to the accident at Chernobyl” (NRC 2006). The U.S. NRC closed out its follow-up research program on Chernobyl in 1992, but still recognizes that the Chernobyl experience should remain a valuable part of the information to be taken into account when dealing with reactor safety issues in the future (NRC 2006).

Although numerous operator errors are documented, several possible design faults in the Chernobyl reactor contributed to the disaster. The Chernobyl reactors are of the RBMK type (Russian acronym for "reactor of high power of the channel type"). These are high-power, pressure-tube reactors, moderated with graphite and cooled with water. (Twelve RBMKs are still in operation in the former Soviet Union. The four reactors at Chernobyl are now all closed (NRC 2006).) The reactor was designed with only partial containment that was bypassed by the accident. Another design fault was related to the reactor core. The RBMK design is unstable when the core is filled with water (that is, small changes in flow or temperature can cause large power changes). Thus, when the reactor core filled with water due to operator error, the capability of emergency shutdown was weakened. Another fundamental weakness in the shutdown system design involved the graphite tips of the control rods. ―The control rods (which are also used for shutdown) travel in vertical tubes, and are cooled by flowing water. Normally, the control rod moves in and out of the reactor to control the power — moving in (adding more neutron absorber) to reduce power and out to increase it. So as the control rod moved in, it would replace the water, and as it moved out, it would be replaced by water. The trouble with this scheme is that water also absorbs neutrons, so the effect of moving the rod would be small. To enhance its effect, at the bottom end of most of the rods there is attached another rod, made of graphite — called a displacer" (AECL 1991). If the control/shutoff rods were then driven slowly in, the first effect would be to replace water (which absorbs neutrons) by graphite (which does not). In this accident, driving in the control/shutoff rods, which was supposed to shut down the reactor, had the opposite effect — it caused a fast power increase instead (AECL 1991).

The only graphite-moderated power reactor in the U.S. was the Fort St. Vrain high-temperature gas-cooled reactor (HTGR) that operated from 1979 to 1989 in Colorado. The NRC assessed the HTGR concept against the issues raised by the Chernobyl accident. NRC staff evaluated aspects of operations, design, containment, emergency planning, and severe accident phenomena and found that the implications of the Chernobyl accident generated no new licensing concerns for HTGRs; general conclusions and those pertaining to specific areas are the same as those for light water reactors (NRC 2007a). As required by NUREG 1251, "Implications of the Accident at Chernobyl for Safety Regulation of Commercial Nuclear Power Plants in the United States," NRC compares the design features of U.S. reactors with those of the Chernobyl 4 reactor in looking for possible regulatory changes implicit in the accident (NRC 2007a).

Three Mile Island

―The accident at the Three Mile Island [TMI] Unit 2 ... nuclear power plant near Middletown, Pennsylvania, on March 28, 1979, was the most serious in U.S. commercial nuclear power plant operating history, even though it led to no deaths or injuries to plant workers or members of the nearby community" (NRC 2007b). The off-site release of radioactivity was very limited at Three Mile Island; however the event is classified as Level 5 on the IAEA event scale based on the on-site impact. ―The sequence of certain events – equipment malfunctions, design-related problems, and worker errors – led to a partial meltdown of the TMI-2 reactor core" (NRC 2007b). A minor short-term radiation dose to the public occurred (within International Commission for Radiation Protection limits) (UIC 2007).

The accident began when the plant experienced a failure in the secondary, non-nuclear section of the plant.

> The main feedwater pumps stopped running, caused by either a mechanical or electrical failure, which prevented the steam generators from removing heat. First the turbine, then the reactor, automatically shut down. Immediately, the pressure in the primary system (the nuclear portion of the plant) began to increase. To prevent that pressure from becoming excessive, the pilot-operated relief valve (a valve located at the top of the pressurizer) opened. The valve should have closed when the pressure decreased by a certain amount, but it did not. Signals available to the operator failed to show that the valve was still open. As a result, cooling water poured out of the stuck-open valve and caused the core of the reactor to overheat...
>
> As coolant flowed from the core through the pressurizer, the instruments available to reactor operators provided confusing information. There was no instrument that showed the level of coolant in the core. Instead, the operators judged the level of water in the core by the level in the pressurizer, and since it was high, they assumed that the core was properly covered with coolant. In addition, there was no clear signal that the pilot-operated relief valve was open. As a result, as alarms rang and warning lights flashed, the operators did not realize that the plant was experiencing a loss-of-coolant accident. They took a series of actions that made conditions worse by simply reducing the flow of coolant through the core...
>
> Because adequate cooling was not available, the nuclear fuel overheated to the point at which the zirconium cladding (the long metal tubes that hold the nuclear fuel pellets) ruptured and the fuel pellets began to melt. It was later found that about one-half of the core melted during the early stages of the accident. Although the TMI-2 plant suffered a severe core meltdown, the most dangerous kind of nuclear power accident, it did not produce the worst-case consequences that reactor experts had long feared. In a worst-case accident, the melting of nuclear fuel would lead to a breach of the walls of the containment building and release massive quantities of radiation to the environment. Fortunately, this did not occur as a result of the Three Mile Island accident [NRC 2007b].

Today, the TMI-2 reactor is permanently shut down and defueled and will be decommissioned when the operating license for TMI 1 expires (NRC 2007b).

<u>TMI Design Faults</u>

Three Mile Island is a PWR, as are 69 of the 104 operating U.S. reactors (EIA 2005). The accident was caused by a combination of personnel error, design deficiencies, and component failures. The problems identified from careful analysis of the events have led to permanent changes in how NRC regulates its licensees (NRC 2007b). The design and equipment deficiencies identified were related to fire protection, piping systems, auxiliary feedwater systems, containment building isolation, reliability of individual components (pressure relief valves and electrical circuit breakers), and the ability of plants to shut down automatically. In addition, NRC required enhancement of emergency preparedness to include immediate NRC notification requirements, and installation of additional equipment by licensees to mitigate accident conditions and monitor radiation levels and plant status (NRC 2007c). The TMI requirements are outlined in 10 CFR 50.34(f), with the exception of the certain combustible gas control that have been superseded by CFR 50.44.

Other Incidents of Known Environmental Contamination

Some events that caused minor releases to the environment are described below (Paks Nuclear Power Plant, Hungary 2003, Indian Point Unit 2, New York 2000, and various tritium releases to groundwater occurring in 2005 and 2006). Incidents of environmental contamination that could not be sufficiently documented for this review are shown in the table below.

Events at Commercial Nuclear Power Plants without Available Detailed Documentation

Date	Nuclear Power Plant	Event
1993	Perry, OH	Fuel rods leaked due to bad end-cap welds. —The root cause of the failures was attributed to undetected manufacturing defects, possibly exacerbated by the Perry operating practice of using control rod movement rather than flow control for minor power adjustments” (NRC 1993).
1987	Oconee, SC	During a refueling outage, a freeze seal was used to enable plant personnel to replace a 3-inch-diameter section of low-pressure injection piping because no valves were available to isolate the affected piping. —The freeze seal was in a line connected to the borated water storage tank, which supplies borated water for the low-pressure injection system. The freeze seal failed, and approximately 30,000 gallons of slightly radioactively contaminated water leaked into various areas of the auxiliary building. A portion of the water from the borated water storage tank drained through the station yard drainage system and flowed past the site boundary before the leak was brought under control 8 hours after the freeze seal failed” (NRC 1991).
1983	Browns Ferry, AL	—While conducting turbine overspeed tests, the reactor scrammed and isolated. Three safety/relief valves (SRVs) were opened. Two reseated but one remained opened, blowing the reactor down to 120 psig, after which the valve appeared to reseat. The unidentified leak that remained was attributed to a vacuum breaker on the SRV tail pipe and the failure to seat was initially blamed on a faulty air solenoid. On restart, the reactor was again depressurized (from 178 psig) by the SRV that had previously failed to reseat. The subsequent licensee investigation showed that the pilot inlet tube mounting bracket had broken, permitting the inlet tube to lodge between the main disc and seat” (NRC 1983).
1982	Ginna, NY	On January 25, 1982, the plant experienced a rupture of a steam generator tube (NRC 1982). The investigation is documented in NUREG-0909 which is not available on the NRC website.
1982	Salem, NJ	Release of a small amount of radioactive gas from a valve inadvertently knocked open by a door (Associated Press 1982).

Paks Nuclear Power Plant, Hungary, 2003

On April 10, 2003, a fuel-cleaning incident occurred at Unit 2 of the Paks nuclear power plant in Hungary. The event was rated as level three on the International Nuclear Event Scale. (Level 3 is defined as a “serious incident,” for which, if offsite impact exists, it is described as a very minimal release in which public exposure is a fraction of the prescribed limits). The reactor remained out of service for over a year, finally resuming commercial electricity production in September 2004.

As a result of this incident, radioactive gases were release through the plant‘s stack. According to preliminary data, 410 TBq (Terabecquerel) noble gases, 360 TBq radioiodine, and 2.5 GBq (Gigabecquerel) radioaerosols were emitted in the first two weeks of the incident. “One half of the noble gases, predominantly xenon-133 and krypton-85m, and the great majority (95 percent) of the activity of the radioiodines (expressed in iodine-131 equivalent), were released in the first day” (Greens/European Free Alliance 2007, Section 9.2.4.1). The time distribution of the radioaerosol emission was similar to that of the radioiodines, though the quantities were much lower. The atmospheric emissions were monitored by continuous measurements of the power plant. “The maximum individual dose for the most exposed members of the population was found to be 0.13 micro-sievert (μSv)[12] as obtained by model calculations based on measured radiological and meteorological data. This value is equivalent to about a one-hour dose from natural background radiation” (Hungarian Atomic Energy Authority 2003). “The radioactive noble gas emissions following the Paks event correspond to roughly four times the cumulated annual emissions of all 58 French PWRs and180 times of their cumulated radioactive iodine and aerosol releases” (Greens/European Free Alliance 2007, Section 9.2.4.1).

The event initiated when Unit 2 was shut down for scheduled maintenance, and 30 fuel assemblies had been removed from the reactor and placed approximately 10 meters under water in a fuel cleaning tank, adjacent to the fuel pool. “The fuel assemblies were being cleaned due to magnetite deposits on their cladding. Initial indications of increased radiation levels led operators to suspect that a fuel assembly was leaking due to the cleaning operation. However, during an inspection that was performed several days later, a video camera revealed that most of the fuel had suffered heavy damage due to insufficient cooling during the fuel cleaning process” (IAEA 2004b).

> It is significant that neither the regulator nor the organization that operates the plant used conservative decision making in the nuclear safety assessment for the unproven fuel cleaning system. They left the responsibility for operation of the system with the contractor. Furthermore, the tight schedule for design, fabrication, installation, testing, and operation of the new fuel cleaning system contributed to a sense of urgency that influenced decisions regarding the rigor of nuclear safety assessment and design review. The Paks plant has dedicated significant personnel resources to the recovery operations and to the prevention of a similar event [IAEA 2004b].

[12] The SI unit for tissue-equivalent radiation dose. 1 sievert (Sv) = 100 rem.

Paks Design Faults

IAEA determined that a poor cleaning tank design, combined with a weak safety analysis and inadequate operational oversight, contributed to the incident (IAEA 2004b).

The Paks Nuclear Power Plant has four reactor units of the type VVER-440 Model V213. These models are second generation Soviet pressurized light water reactor designs. Water is used to generate steam and to cool the reactor and also acts as a moderator (NEI 1997). On February 24, 2004, NRC issued an Information Notice about the Paks event (NRC 2004). The notice stated that though the fuel cleaning system involved was not of domestic (U.S.) design or manufacture, the fuel and processes used at the affected PWR were similar to those that may be used in domestic light-water reactors. NRC also stated that:

> This event demonstrates the importance of maintaining adequate cooling of fuel after discharge from the reactor vessel. In this event, the design features that provide adequate natural circulation cooling were not maintained in the design of the cleaning system. Instead, the cleaning system design relied on forced circulation cooling without adequate consideration of the reliability and capability provided for this function. The damage to the integrity of the fuel, which resulted from the inadequate cooling, threatened the maintenance of an adequate margin to criticality and released a substantial quantity of radioactive material to the environment [NRC 2004].

During cleaning, the cooling of the fuel was insufficient because of deficiencies in the design of the cleaning system, specifically: (1) the capacity of the cooling water pump was not large enough for the job; (2) the location of the outlet of the inner vessel at the bottom enabled it to become partially clogged with corrosion deposits; (3) available paths for water that would bypass the fuel elements (and hence not contribute to cooling) were recognized but not addressed effectively; (4) slight mis-alignment of the fuel in the cleaning chamber would reduce cooling flow, yet there was only one fuel guide plate; (5) the time to boiling in the case of insufficient cooling was very small" (Ghosh and Apostolakis 2005).

Indian Point Unit 2, New York, 2000

A steam generator tube failure at Indian Point Unit 2 in Buchanan, New York, occurred on February 15, 2000, which resulted in a minor radiological release to the environment that was well within regulatory limits. No radioactivity was measured off-site above normal background levels, and the event did not impact public health and safety. Indian Point Unit 2 is a commercial nuclear power plant operated by Consolidated Edison Company, located about 24 miles north of New York City.

The series of events leading to the release is described in the abnormal occurrence report. The steam generator is a heat exchanger which allows heat to pass from the reactor (primary system) to the turbine generator (secondary system). It also provides the boundary between the radioactive primary system and the non-radioactive secondary system. Indian Point Unit 2 has four steam generators, each with approximately 3,300 tubes. On the date of the incident, one of these tubes failed, allowing reactor water to leak into the secondary system. Operators took steps to isolate the steam generator which contained the leaking tube. Operators began to cool down the plant after the steam generator was isolated. They were then forced to suspend the cooldown process when they realized they had inadvertently established an excessive cooldown rate. This excessive cooldown rate caused a rapid reduction in reactor coolant system (pressurizer) level. Borated water was pumped into the reactor coolant system to restore the coolant level, using the safety injection system. When this was accomplished, cooldown was resumed, and cold shutdown was achieved (NBRC 2001-2007).

–The steam generator tube failure resulted in an initial primary-to-secondary leak of reactor coolant of approximately 146 gallons per minute, and required an "Alert" declaration. This event involved some procedural and equipment issues that challenged operators, complicated the event response, and delayed achieving the cold shutdown condition" (NRC 2001-2007). It caused significant public and media interest, and required increased NRC attention.

Indian Point Design Fault

–Following the event, the NRC performed an inspection and determined that Consolidated Edison Company had not performed an adequate examination of the steam generator tubes during its 1997 outage. As a result, degraded tubes were allowed to remain in service during plant operation, which ultimately led to a steam generator tube failure" (NRC 2001-2007).

Radiological Releases to Groundwater (Various Plants)

Recent events at several nuclear power plants have highlighted a concern with tritium contamination of groundwater as a result of unplanned releases, such as those due to equipment degradation. Tritium was identified as the primary source of contamination. Tritium is a low radioactive hydrogen isotope that occurs both naturally and during NPP operation. Tritium is normally released within the permitted liquid effluents from NPPs (NRC 2001-2007). In addition to tritium, releases of cobalt-58, cobalt-60, cesium-134, cesium-137 nickel-63, and strontium-90 were detected at some plants (NRC 2006c). Although none of the releases were considered –abnormal occurrences," they generated significant public, Congressional, and media interest (NRC 2001-2007).

NRC established a Liquid Radioactive Release Lessons Learned Task Force, which concluded that the maximum potential dose in all of these incidents, a dose unlikely to have been received by any person outside the plants' boundaries, was less than the dose an average individual in the U.S. receives in one day during the course of routine activities from naturally occurring radiation sources, and was well below the regulatory limit for planned releases (NRC 2007d). The table below provides a summary of the inadvertent releases of radioactive liquids described in the Task Force report. The events generally occurred from 1996 to 2006, but an event from 1986 is also included because it resulted in a notice of violation and proposed imposition of a civil penalty. The Task Force report notes that this is not a complete list but rather a cross-section of events. In addition, contamination has been identified at numerous decommissioning sites (NRC 2006c).

Inadvertent Releases of Radioactive Liquids at Nuclear Power Plants

Plant	Release Discovered	Source of Release	Radionuclides Detected
Braidwood	March 2005	Leaking vacuum breaker valves on the circulating water blowdown line	Tritium
Byron	February 2006	Leaking vacuum breaker valves on the circulating water blowdown line	Tritium
Callaway	June 2006	Leaking vacuum breaker valves on the circulating water blowdown line	Tritium, cobalt-58, cobalt-60, cesium- 134, cesium-137
Dresden	August 2004, January 2006	Potential leak in the underground, non-safety, high pressure coolant injection system suction and return piping, which is connected to the condensate storage tank. Investigation continues.	Tritium
Hatch	December 1986	Operational/configurational control errors resulted in the deflation of Spent Fuel Pool seals and the resultant release	Tritium
Indian Point	August 2005 - Unit 1 leakage predates August 2005	Cracks in Unit 1 and Unit 2 spent fuel pools	Tritium, nickel-63, cesium-137, strontium-90, and cobalt-60
Oyster Creek	September 1996	Inadvertent discharge of radioactively contaminated water to the environment from the condensate transfer system. The cause of the discharge was attributed to an operator opening an incorrect valve when placing a temporary system in service.	Tritium
Palo Verde	March 2006	Plant staff concluded that most of the elevated onsite tritium contamination was due to past operational practices during boric acid concentrator system (evaporator system) releases, resulting in rain deposition and washdown of roof drains. Prior to the mid-1990s, the licensee allowed evaporator system batch releases to occur during rainy days. During those releases, gaseous tritiated vapors were condensed by rain, and the resulting water runoff on the site was absorbed into the ground and also ran into the storm drain system.	Tritium
Perry	March 2006	Leakage from a flange in the feedwater system venturi. The leakage migrated through two elevations, through gaps, cracks, and spaces between structures, and into the underdrain system.	Tritium
Point Beach	1999	Contamination near a retention pond was apparently the result of a steam generator tube leak in 1975 and leakage from a buried pipe in 1997	Tritium, cesium-137
Seabrook	June 1999	The source of the tritium leakage was from a defect in the liner of the cask loading pool, which is connected to the fuel transfer canal in the Fuel Handling Building	Tritium

Plant	Release Discovered	Source of Release	Radionuclides Detected
Salem	September 2002	Contamination was due to Unit 1 Spent Fuel Pool water leaking into a narrow seismic gap between the Unit 1 Auxiliary Building and Unit 1 Fuel Handling Building, and entered the Mechanical Penetration Room. Further licensee reviews determined that the tell-tale drain system for the Unit 1 spent fuel pool had become obstructed, which caused a buildup of water between the spent fuel pool liner and concrete structure. The water then migrated through a wall and penetrations. Further investigation revealed that the seismic gap was ultimately connected to groundwater.	Tritium
Three Mile Island	May 2006	Engineers identified the source of the tritium water leak to be an underground four inch de-icing line, within the protected area, from the condensate system to the condensate storage tank. Contaminated water from the condensate system reached a parking lot via an underground telephone cable conduit run. The water had entered a below floor grade telephone cable raceway which allowed the contaminated water to flow into the cable conduit run	Tritium
Watts Bar	August 2002	One source was small leaks in a radioactive liquid effluent line which resulted in a dual branch plume of tritium. A second source was a leakage through the fuel transfer tube sleeve into the Shield Building annulus of the abandoned Unit 2 facilities with the tritium migrating into the ground water adjacent to the shield building.	Tritium and mixed fission products

Source: NRC 2006c.

Design Faults Related to Radiological Releases

All of the releases described above were caused by undetected leakage from facility structures, systems, or components that contain or transport radioactive fluids. For example, at the Indian Point nuclear power plant, unintended releases of tritium through a crack in the spent fuel pool concrete support wall may have been the cause of the elevated levels of tritium in groundwater in the area immediately surrounding the plant's spent fuel pool. In another instance, at the Braidwood nuclear power plant, unintended releases of tritium from a number of vacuum breaker valves at the plant caused elevated levels of tritium in groundwater in unrestricted, public areas (NRC 2007d). In addition to design faults, the sources and pathways of contamination described in the table above point to equipment degradation, inadequate system maintenance, delayed detection of leaks, and operator errors as root causes of ground water contamination.

An Information Notice published in July 2006 (NRC 2006b) describes the situations at each of the affected plants and identifies several points associated with groundwater contamination events. The notice points out that leakage from structures, systems, or components that contain and transport radioactive fluids may not be easily detectable due to small leakage rates or because the area near the point of leakage is not subject to routine radiological monitoring. Therefore, “representative sampling and analysis of onsite ground water may be the only viable method to detect this leakage and the subsequent migration of the contamination, particularly for subsurface leakage” (NRC 2006b) (for example, leakage from a buried pipe). Though the information notice places no new requirements on licensees, it points out potential causes of groundwater contamination and the risks associated with inadequate monitoring data to detect contamination such as leakage from the environment back into the facility, increased decommissioning costs in the future, and the possibility of unmonitored, unassessed exposure pathways to members of the public (NRC 2006b).

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Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

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Appendix F. Summarized Listing of Review Questions

1. Introduction

- Has the purpose and need for the action been described?
- Has the need for power been assessed (as Chapter 8 of EIS if following NRC guidance)?
- Is a summary provided of related NEPA documents and other environmental and safety reports?
- Have all applicable regulatory requirements, permits, and agency consultations been identified in the EIS?
- In the case of a COL Supplemental EIS to an existing Final EIS for an ESP:
    - Does the design of the facility fall within the site and design parameters of the ESP?
    - Does it resolve any significant environmental issues that were deferred to the COL stage?
    - Does it identify any new and significant information affecting previous conclusions regarding impacts?
    - Were impact analyses described as already existing and therefore not repeated in the COL supplement conducted fully and completely, and were their conclusions accurately brought forward?

2. Plant Description

- Does the EIS fully describe all aspects of plant design, construction, and operation?
- Does the EIS clearly breakout the pre-construction activities (evaluated only in terms of cumulative impacts) from those that are part of full plant construction and operation, so that the impacts of each can be clearly differentiated?
- Does it fully describe the cooling system, including the following aspects?
  - operational modes to address potential impacts of heat dissipation
  - projected water needs and potential impacts to downstream water use/consumption
  - information on use of biocides or other chemicals anticipated to be used to control organisms in the cooling system
  - information on water quality permits and current status
  - thermal aspects of the cooling system
  - design details of the heat dissipation system components
- Does the EIS describe the water treatment that will be required for plant operation, including pre-use treatment of cooling water and treatment of plant waste streams?
- Does the EIS include a full description of the radioactive waste management system, nonradioactive waste systems, plant effluents (containing chemicals or biocides), sanitary system effluents, and other effluents?

3. Environmental Description (Affected Environment)

- Is the existing environment described in sufficient detail to form a basis for evaluating the potential for direct, indirect, and cumulative impacts?
- For resource elements where there are significant impacts, does the environmental description section provide the needed background for adequately assessing the impact for that resource?
- Does the discussion emphasize the resources that are most likely to be affected, such as water and socioeconomics?
- Is the environment described on an appropriate scale: site, vicinity, region, and, for cumulative impact analysis, transmission corridors?
- Does the EIS use quality data from reliable sources?
- Are historic changes and trends affecting a resource or feature described?
- For a COL application evaluated in a Supplemental EIS to an existing Final EIS for an ESP, does the discussion rely appropriately on the existing analysis and only supplement this information as required?
- If the NPP will be co-located at an existing power plant site, does the analysis update, as needed, information from previous NEPA analyses that are incorporated by reference or to which the new EIS tiers?

Meteorology and Air Quality

- Does the EIS contain adequate information on climate (wind, atmospheric stability, temperature, atmospheric moisture, severe weather, meteorological monitoring)?
- Does the EIS describe existing air quality, including non-attainment or maintenance areas?

Water Resources

- Does the EIS fully describe surface water hydrology?
- Does the EIS fully describe surface water use?
- Does the EIS fully describe surface water quality?
- Does the EIS fully describe ground water hydrology?
- Does the EIS fully describe ground water use?
- Does the EIS fully describe ground water quality?
- Does the EIS address water rights issues (particularly in the western U.S.)?

Ecological Resources

- Does the EIS describe terrestrial features of the site, vicinity, region, and (for cumulative impacts) transmission corridors?
- Does the EIS describe aquatic features of the site, vicinity, region, and (for cumulative impacts) transmission corridors?

- Does the EIS describe endangered, threatened, or other sensitive species and any special habitats?

Cultural and Historic Resources

- Does the EIS identify any cultural, historic, or traditional resources in the site, vicinity, region, and (for cumulative impacts) transmission corridors?
- Does the EIS describe the results of any cultural resources surveys?
- Does the EIS identify whether there are any National Register of Historic Places listed or eligible properties in the site, vicinity, region, and (for cumulative impacts) transmission corridors?

Socioeconomics

- Does the EIS include demographic data describing the population within 16 km (10 miles), the population between 16 and 80 km (10 and 50 miles), and the demographic characteristics of the 0- to 80-km (0- to 50-mile) enclosed population?
- Does the EIS identify permanent and transient populations?
- Does the EIS summarize community characteristics?
- Has information been included on potentially affected minority and low-income populations and whether they may interact with the environment in ways that create unique exposure pathways?

Geology and Seismology

- Have the geological and soil conditions been adequately described?
- Have any geologic hazards been noted?
- Have the seismic evaluation findings been summarized?

4. Site Layout and Plant Parameter Envelope

- If the EIS is for a COL or an operating license, it must specify the reactor design.
- Does this chapter present the overall appearance of the facility and the layout (with a map) of onsite and offsite plant structures?
- Are there any plans for secluding and screening the facilities visually, or for aesthetic design concepts?
- Does the EIS provide adequate detail to support the impact assessment regarding:
  - Reactor power conversion system
  - Plant water use
  - Water consumption
  - Water treatment
  - Cooling system
  - Radioactive waste management system
  - Nonradioactive waste systems
  - Power transmission systems
  - Power transmission system
  - Transportation of radioactive materials
- Are all the quantitative and qualitative descriptions set forth in the Plant Description chapter consistent with the assumptions presented in the environmental impact analysis chapters?

5. Construction Impacts

- Are all activities that are considered “preconstruction” identified as such, and analyzed for cumulative impacts?
- Are the plant-specific construction plans clear enough so that the reader can understand whether all areas of potential impact have been appropriately identified and evaluated in the EIS?
- For a COL application evaluated in a Supplemental EIS to an existing Final EIS for an ESP, does the discussion rely appropriately on the existing analysis and only supplement this information as required?

Land Use

- Does the EIS identify any potential conflicts among federal, state, local, or tribal land use plans, including coastal zone management areas?
- In evaluating cumulative impacts, does the EIS identify the total acreage and current land uses that will be affected by construction?
- Does the EIS include an appropriately detailed assessment of the cumulative impacts from upgrades to any existing transmission system and the extent to which existing rights-of-way may be used, proposed routing and distance/length of new rights-of-way, general methods of construction, and existing land uses along corridors?

Historic Resources

- Are potential effects on historic properties considered, in terms of cumulative impacts due to preconstruction and any direct impacts from construction?
- Does the EIS summarize any surveys and consultation regarding cultural and historic resources?

Air Quality

- Does the EIS clearly explain models and assumptions used to quantify air emissions and air quality impacts?
- Does the EIS describe impacts in terms of duration, severity, their likelihood of occurring, and regulatory compliance?
- Does the EIS list the construction permits, notices, and approvals required to comply with the Clean Air Act, Prevention of Significant Deterioration regulations, and state regulations?
- If the site is in an area of non-attainment or maintenance, has a conformity analysis been conducted for construction emissions?

Water

- Does the EIS describe any hydrological alterations occurring during construction?
- Does the EIS state how water for construction activities will be obtained and evaluate impacts?

Ecological Resources

- Have construction effects on aquatic species and habitat been considered?
- Have potential effects to benthic communities (from dredging) been considered, such as the disruption of potentially contaminated bottom sediments?
- Have pre-construction impacts on terrestrial habitat (destruction, loss of vegetative cover) been identified for consideration as cumulative impacts in the analysis?
- Does the EIS consider impacts to ecosystems as a whole, in addition to impacts to key organisms?
- Does the analysis evaluate impacts to both common and protected species and both resident and transient species?
- Does the discussion explain the methods or models used to evaluate ecosystem impacts?
- Is compliance documented with the relevant requirements of the Endangered Species Act, Migratory Bird Treaty Act, Fish and Wildlife Coordination Act, Bald and Golden Eagle Protection Act, and Coastal Zone Management Act?

Socioeconomics

- Have construction workforce impacts been adequately and appropriately assessed in terms of available community services and infrastructure?
- Does the evaluation of physical impacts (such as noise, odors, visual) provide context in terms of construction location relative to sensitive receptors?
- Is the assessment of public service, housing, and other local economic impacts correlated with the availability of local labor?
- Does the environmental justice analysis address the following questions:
  - Are the radiological or other health effects significant or above generally accepted norms?
  - Is the risk of rate of hazard significant and appreciably in excess of the general population?
  - Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
  - Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
  - Are there any significant adverse impacts on a group that appreciably exceed or [are] likely to appreciably exceed those in the general population?
  - Do the environmental effects occur or would they occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? [NRC 2004b, Appendix D-10]
- Does the analysis of potential environmental justice issues consider the following:
  - The locations of minority and low-income population residential areas relative to the construction site.
  - Any past benefits from construction and operation of the previous / current generation of plants.

- The skill levels required for construction and the extent to which construction employment could be supplied by minorities and low-income populations.

Radiation Exposure to Construction Workers

- Does the EIS summarize annual radiation doses to construction workers from adjacent operating unit(s), including exposures from direct radiation, gaseous effluent releases, and liquid effluent releases?
- Does the analysis include models, assumptions, and input data?

Waste

- Are construction waste impacts evaluated in the EIS?
- Is waste generated in association with preconstruction activities assessed as a cumulative impact?

6. Operational Impacts

Land Use

- Does the EIS evaluate the potential for effects to surrounding land uses from cooling tower plumes or spray pond operations, including the impacts of salt drift, fogging, cloud cover, relative humidity, icing, and biocide drift?
- Does the EIS address the cumulative effect of long-term restrictions of land use and long-term changes in land use of the site and vicinity (including lands classified as floodplains and wetlands, prime farmland)?
- Does the EIS identify potential conflicts between federal, state, local, or Indian land use plans?
- Does the EIS discuss the proposed plant location as it relates to local land-use planning and proposed nearby future land uses, for consideration of operational impacts?
- If land use is assessed within separate construction and operation impacts chapters, the EPA reviewer should ensure that the two discussions are consistent and together present a comprehensive assessment.
- Does the EIS address the cumulative impacts on land use from new transmission line construction or upgrades that could occur during the course of operation?

Historic Resources

- If mitigation measures to protect historic properties during construction were identified, measures to extend the same protections during operation should be noted in the EIS.

Meteorology and Air Quality

- Has an effective meteorological monitoring plan been developed?
- Have air quality impacts from a cooling tower‘s plume been evaluated, including heat and moisture?
- Have routine nonradiological air emissions been quantified, including generator / boiler and worker vehicle emissions?

Water Resources

- Does the EIS include sufficient water use data and info to assess impacts of proposed project construction and operation on consumptive and non-consumptive water uses?
- Will the proposed action affect any EPA mandates, particularly water quality?
- Are potential conflicts with other (downstream) water users addressed? Have impacts on downstream water quality and shoreline been evaluated?
- Have potential impacts from contaminated sediments, if present in water bodies where dredging occurs, been considered?
- Has an effective monitoring plan been developed for thermal monitoring of surface water?

- Has an effective monitoring plan been developed for water quality and supply impacts on surface water, including permitted releases?
- Has an effective monitoring plan been developed for water quality and supply impacts on groundwater?
- Has an effective radiological monitoring plan been developed that includes surface water, groundwater, drinking water, and sediment?
- Has an effective chemical (non-radiological) monitoring plan been developed?
- Does the EIS provide assurance that the NPP will have access to a sufficient (even during periods of drought) and long-term water supply (for 40-year period of operation)?
- Are hydrological alterations from NPP operation predicted? What will the impact be on components of the aquatic environment?
- If gray water, brackish water, or wastewater effluent will be used, does the EIS evaluate impacts resulting from provisions for any required treatment (such as an onsite treatment plant)?
- Does the EIS describe the plant's operational modes to adjust to water supply changes?
- If a plant is co-located with an existing nuclear plant (or coal plant that also has large water requirement), cumulative impacts on water quality from both plants should be addressed.

Ecological Resources

- Would the proposed action cause substantial damage to the ocean and coastal habitats?
- Have the effects of adverse water quality been on aquatic resources been considered?
- Have operational effects on aquatic species and habitat been considered, including effects of thermal discharges?
- Have impacts to threatened and endangered species been considered?
- Does the EIS consider impacts to ecosystems as a whole, in addition to key organisms?
- Have impacts on terrestrial habitat been considered?
- Have ecological impacts been addressed from cooling tower drift, fogging and icing, bird collisions, cooling ponds, electromagnetic fields, right-of-way management, and consumptive water uses?
- Has an effective ecological monitoring plan been developed that includes terrestrial ecology and aquatic ecology?
- Does EIS include a summary of applicable/required consultations with appropriate federal, state, regional, local, and Indian tribal agencies, including the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and the state fish and wildlife agency?

Radiological Impacts from Routine Operations

- Have radiological air emissions been quantified?
- Has the potential for direct radiation exposure been addressed?

- Does the EIS describe the sources of and amounts of liquid radioactive wastes?
- Does the EIS adequately describe the potential exposure pathways to support the estimates of radiation doses to members of the public?
- Does the analysis identify receptor locations, including schools, hospitals, and residences, and any locations at which plants or animals that become food for the public may be exposed to either direct radiation or contamination?
- Does the analysis quantify doses to the general population (within 50 miles) and the maximally exposed individual?
- Is the radiological risk characterization consistent with EPA, NRC, and other appropriate standards and criteria?
- Have impacts to the workers (involved and non-involved) been addressed?
- Have impacts from postulated accidents been addressed? These include design basis accidents and severe accidents, such as caused by extreme weather or a geologic/seismic event. Potential pathways to be evaluated should include air, surface and groundwater (potential tritium concerns, drinking water), food ingestion (agriculture, irrigation). NRC now also requires the consideration of design alternatives to mitigate the consequences of severe accidents.
- Has an effective radiological monitoring plan been developed that includes airborne radioiodine and particulates, direct radiation, ingestion exposure (milk, fish and invertebrates, plant-based food products), and the parameters previously identified under the Water section?
- Does the EIS evaluate the impacts of radioactive effluents on terrestrial plants and animals, and on aquatic organisms?

Waste

- Does the EIS thoroughly characterize chemical discharges, including treatment systems, concentrations, and chemicals used?
- Does the EIS describe plant systems producing mixed waste, mixed waste storage plans, mixed waste disposal plans or capabilities, and assess both radiological and nonradiological mixed waste impacts?

Socioeconomic Impacts

- Have noise impacts been identified and evaluated?
- Have visual impacts been identified and evaluated?
- Does the EIS adequately analyze the effects on local traffic patterns and transportation infrastructure?
- Have environmental justice issues been addressed?
- Does the environmental justice analysis address the following questions:
  - Are the radiological or other health effects significant or above generally accepted norms?

- Is the risk of rate of hazard significant and appreciably in excess of the general population?
- Do the radiological or other health effects occur in groups affected by cumulative or multiple adverse exposures from environmental hazards?
- Is there an impact on the natural or physical environment that significantly and adversely affects a particular group?
- Are there any significant adverse impacts on a group that appreciably exceed or [are] likely to appreciably exceed those in the general population?
- Do the environmental effects occur or would they occur in groups affected by cumulative or multiple adverse exposure from environmental hazard? [NRC 2004, Appendix D-10]

Accidents

- ➢ Does the EIS describe and summarize the radiological consequences of the design basis accidents that may result in environmental releases?
- ➢ Are severe accident mitigation alternatives summarized?
- ➢ Do EISs prepared for facilities located within the Ninth Circuit include an analysis of the impact of a terrorist act?

7. Transportation of Radioactive Materials

- Has transportation of radioactive materials been evaluated, including potential accidents during shipping?

8. Nuclear Fuel Cycle

- Does the EIS address the environmental impacts of the nuclear fuel cycle attributable to the proposed NPP?
- Are the standard NRC data modified as appropriate to reflect the details of the proposed reactor design when characterizing the environmental effects?
- If other than a light water reactor is proposed, does the EIS present the basis for evaluating the contribution of the environmental effects of fuel cycle activities?
- Have reasonable assumptions been made about the onsite storage of spent fuel?

9. Decontamination and Decommissioning

- At a minimum, does an ESP EIS incorporate by reference the appropriate portions of the decommissioning impact analysis from the Generic EIS on Decommissioning of Nuclear Facilities?
- For NEPA documents at later stages than an ESP, do the actions and conditions at that NPP fall within the bounds of the generic analysis?
- For NEPA documents at later stages than an ESP, has site-specific analysis been documented for endangered and threatened species, environmental justice, and, as appropriate, land use, aquatic ecology, terrestrial ecology, and cultural and historic resources?

10. Mitigation Actions and Requirements

- Does the EIS consider mitigation for all impact areas, emphasizing steps to address those impacts with the greatest potential for significance?
- Does the EIS evaluate pollution prevention strategies and technologies beyond those inherent in the proposed NPP design?
- Does the EIS indicate whether implementing a mitigation measure is within NRC‘s jurisdiction?
- Does the EIS demonstrate that affected communities have been involved in developing mitigation measures when necessary?

11. Cumulative Impacts

- Does the EIS consider the potential for cumulative effects of the proposed action and other activities in the area under consideration, including pre-construction activities?
- If applicable, have potential cumulative impacts from a proposed facility and operation of a co-located existing facility been considered?

12. Irreversible and Irretrievable Commitment of Resources

- Does the EIS evaluate irreversible and irretrievable commitments of resources?

13. Short-Term Uses vs. Long-Term Productivity

- Does the EIS evaluate short-term uses vs. long-term productivity?

14. Alternatives

- Do the proposed action and reasonable alternatives achieve the stated purpose and need?
- Is the proposed action clearly defined and described?
- Is the no action alternative clearly identified and described in sufficient detail so that its scope is clear and potential impacts can be identified?
- Has a reasonable range of alternatives been considered?
  - Has the region of interest been identified and does it appear reasonable, given the type of plant proposed and the service area it will be supporting?
  - Has the range of sites been unduly narrowed to predetermine the outcome of the alternative site review?
  - Are the alternative sites identified the best that can be reasonably be found for the siting of a nuclear power plant, or have potential sites been omitted?
  - Have existing power plants within the region of interest been considered, as well as potential greenfield, brownfield, and other sites?
  - Has sufficient information been presented to explain why alternatives eliminated from detailed study were eliminated?
- Are the alternatives treated fairly and in an even-handed manner? Have the candidate sites been evaluated in sufficient detail to support selection of the proposed action and alternative sites?
- Are the environmental impacts of alternatives presented in a comparative form to sharply define the issues and provide a clear basis for choice among alternatives? Is sufficient information presented to allow the decision maker or other readers to evaluate differences among them?
- Has the analysis shown that none of the alternative sites is obviously superior to the proposed site?

15. Comparison of Proposed Action and Alternatives

- Does the EIS present a comparison of the environmental impacts by alternative?

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Appendix G. Key Federal Statutes, Regulations, and Executive Orders

National Environmental Policy Act, http://www.nepa.gov/nepa/regs/nepa/nepaeqia.htm Requires federal agencies to conduct an environmental review of major federal actions significantly affecting the quality of the environment before making decisions.

Council on Environmental Quality Regulations for Implementing NEPA, http://www.nepa.gov/nepa/regs/ceq/toc_ceq.htm. Contains requirements for preparing EISs and environmental assessments.

10 CFR Part 50 – Domestic Licensing of Production and Utilization Facilities, http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr50_08.html. Provide for the licensing of nuclear materials production and utilization facilities.

10 CFR Part 51 – Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions, http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr51_08.html. Environmental protection regulations applicable to NRC's domestic licensing and related regulatory functions, including NEPA implementation.

10 CFR Part 52 – Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants, http://www.access.gpo.gov/nara/cfr/waisidx_08/10cfr52_08.html. Governs the issuance of early site permits, standard design certifications, combined licenses, standard design approvals, and manufacturing licenses for nuclear power facilities.

Archaeological Resources Protection Act, http://www.nps.gov/history/local-law/FHPL_ArchRsrcsProt.pdf. Secures, for the present and future benefit of the American people, the protection of archaeological resources and sites that are on public lands and Indian lands, and fosters increased cooperation and exchange of information between governmental authorities, the professional archaeological community, and private individuals having collections of archaeological resources and data

Bald and Golden Eagle Protection Act, http://www.fws.gov/permits/mbpermits/regulations/BGEPA.PDF. Provides for the protection of the bald eagle and the golden eagle by prohibiting, except under certain specified conditions, the taking, possession, and commerce of such birds

Clean Air Act, http://epw.senate.gov/envlaws/cleanair.pdf. Provides EPA with broad authority to implement and enforce regulations reducing air pollutant emissions; authority for some aspects may be delegated to states and tribes.

Clean Water Act, http://epw.senate.gov/water.pdf. Establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters.

Coastal Barrier Resources Act, http://www.access.gpo.gov/uscode/title16/chapter55_.html. Designated various undeveloped coastal barrier islands, depicted by specific maps, for inclusion in the Coastal Barrier Resources System. Areas so designated were made ineligible for direct or indirect Federal financial assistance that might support development, including flood insurance, except for emergency life-saving activities. Exceptions for certain activities, such as fish and wildlife research, are provided, and National Wildlife Refuges and other, otherwise protected areas are excluded from the System.

Coastal Zone Management Act, http://www.access.gpo.gov/uscode/title16/chapter33_.html. Encourages states/tribes to voluntarily preserve, protect, develop, and where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. 1990 amendments call upon states/tribes with federally approved coastal zone management programs to develop and implement coastal nonpoint pollution control programs.

Emergency Planning and Community Right-to-Know Act, http://www.access.gpo.gov/uscode/title42/chapter116_.html. Also known as Title III of the Superfund Amendments and Reauthorization Act. Enacted as the national legislation on community safety; designed to help local communities protect public health, safety, and the environment from chemical hazards.

Endangered Species Act, http://www.fws.gov/endangered/pdfs/ESAall.pdf. Provides for conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend. Among other provisions, the Act authorizes the determination and listing of species as endangered and threatened; prohibits unauthorized taking, possession, sale, and transport of endangered species; authorizes the assessment of civil and criminal penalties for violating the Act or regulations; and requires federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

Energy Policy Act, http://www.access.gpo.gov/uscode/title42/chapter134_.html. Provides tax incentives for domestic energy production and energy efficiency, a mandate to double the nation‘s use of biofuels, repeal of restrictions on interstate utility holding companies, faster procedures for energy production on federal lands, and authorization of numerous federal energy research and development programs.

Farmlands Protection Act, http://www.nrcs.usda.gov/programs/fppa/pdf_files/FPPA_Law.pdf. Establishes criteria for identifying and considering the effects of federal actions on the conversion of farmland to non-agricultural uses.

Fish and Wildlife Coordination Act, http://www.access.gpo.gov/uscode/title16/chapter5a_subchapteri_.html. Goal is to protect, rear, stock, and increase the supply of game and fur-bearing animals, as well as to study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife. Requires consultation with Fish and Wildlife Service on actions affecting stream modifications.

Magnuson-Stevens Fishery Conservation and Management Act, http://www.nmfs.noaa.gov/sfa/magact/. Governs the conservation and management of ocean fishing. Establishes exclusive U.S. management authority over all fishing within the exclusive economic zone, all anadromous fish throughout their migratory range except when in a foreign nation's waters, and all fish on the continental shelf.

Marine Mammal Protection Act, http://www.nmfs.noaa.gov/pr/pdfs/laws/mmpa.pdf. Prohibits, with certain exceptions, the "take" of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the U.S.

Marine Protection, Research, and Sanctuaries Act, http://epw.senate.gov/mprsa72.pdf. Also known as the Ocean Dumping Act; prohibits the dumping of material into the ocean that would unreasonably degrade or endanger human health or the marine environment.

Migratory Bird Treaty Act, http://www.fws.gov/permits/mbpermits/regulations/mbta.html. Implements the United States' commitment to four bilateral treaties (with Canada, Mexico, Japan, and Russia) protecting migratory birds.

National Historic Preservation Act, http://www.achp.gov/NHPA.pdf. Requires agencies to identify historic properties subject to effect by their actions, and to consult with State Historic Preservation Officer and others about alternatives and mitigation.

Occupation Safety and Health Act, http://www.access.gpo.gov/uscode/title29/chapter15_.html. Ensures worker and workplace safety.

Safe Drinking Water Act, http://epw.senate.gov/sdwa.pdf. Protects the quality of all waters in the U.S. actually or potentially designed for drinking use, whether from above ground or underground sources.

Wild and Scenic Rivers Act, http://www.rivers.gov/wsract.html. Requires agencies to review actions for possible impacts of wild and scenic rivers.

Executive Orders

11593: Protection and Enhancement of the Cultural Environment, https://propertydisposal.gsa.gov/RedinetDocs/Env/EO11593.pdf.

11988: Floodplain Management, http://www.eh.doe.gov/nepa/tools/guidance/Guidance-PDFs/14632.pdf.

11990: Protection of Wetlands. http://www.eh.doe.gov/nepa/tools/guidance/Guidance-PDFs/14633.pdf.

12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, http://www.eh.doe.gov/nepa/tools/guidance/Guidance-PDFs/ii-5.pdf.

13007: Indian Sacred Sites, http://www.achp.gov/EO13007.html.

13045: Protection of Children from Environmental Health Risks and Safety Risks, http://www.nepa.gov/nepa/regs/eos/eo13045.html.

13089: Coral Reef Protection, http://www.nepa.gov/nepa/regs/eos/eo13089.html.

13175: Consultation and Coordination with Indian Tribal Governments, http://www.nepa.gov/nepa/regs/eos/eo13175.html.

13186: Responsibility of Federal Agencies to Protect Migratory Birds, http://www.nepa.gov/nepa/regs/eos/eo13186.html.

Appendix H. Useful Tools for Quick Reference

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

This appendix compiles a list of useful tools for quick reference for the reviewer of a nuclear power plant EIS.

Appendix H. Useful Tools for Quick Reference

- NRC Regulations
- NRC Regulatory Guides
- NUREG Series Publications
- Other NRC Resources
- Certified Designs
- EPA Regulations and Tools
- U.S. Department of Energy
- Industry Associations / Nuclear Energy Proponents
- Information Relating to Public Opinion
- Perspectives from Public Interest Groups

NRC Regulations

10 CFR Part 50, Domestic Licensing of Production and Utilization Facilities

> The regulations in this part provide for the licensing of production and utilization facilities. This part also gives notice to all persons who knowingly provide to any licensee, applicant, contractor, or subcontractor, components, equipment, materials, or other goods or services, that relate to a licensee's or applicant's activities subject to this part, that they may be individually subject to NRC enforcement action for violation of § 50.5.
> http://www.nrc.gov/reading-rm/doc-collections/cfr/part050/full-text.html

10 CFR Part 51, Environmental Protection Regulations for Domestic Licenses and Related Regulatory Functions

> This part contains environmental protection regulations applicable to NRC's domestic licensing and related regulatory functions. These regulations do not apply to export licensing matters within the scope of part 110 of this chapter or to any environmental effects which NRC's domestic licensing and related regulatory functions may have upon the environment of foreign nations. Subject to these limitations, the regulations in this part implement the *National Environmental Policy Act* of 1969, as amended.
> http://www.nrc.gov/reading-rm/doc-collections/cfr/part051/full-text.html

10 CFR Part 52, Licenses, Certifications and Approvals for Nuclear Power Plants: Early Site Permits; Standard Design Certifications; and Combined Licenses for Nuclear Power Plants

> This part governs the issuance of early site permits, standard design certifications, combined licenses, standard design approvals, and manufacturing licenses for nuclear power facilities. This part also gives notice to all persons who knowingly provide to any holder of or applicant for an approval, certification, permit, or license, or to a contractor,

subcontractor, or consultant of any of them, components, equipment, materials, or other goods or services that relate to the activities of a holder of or applicant for an approval, certification, permit, or license, subject to this part, that they may be individually subject to NRC enforcement action for violation of the provisions in 10 CFR 52.4. http://www.nrc.gov/reading-rm/doc-collections/cfr/part052/full-text.html

10 CFR Parts 2, 50, 51, 52, 100. Limited Work Authorizations for Nuclear Power Plants. NRC Final Rule (72 FR 57416, October 9, 2007).

The NRC amended its regulations applicable to limited work authorizations (LWAs), which allow certain construction activities on production and utilization facilities to commence before a construction permit or combined license is issued. This final rule modified the scope of activities that are considered construction for which a construction permit, combined license, or LWA is necessary; specifies the scope of construction activities that may be performed under an LWA, and changes the review and approval process for LWA requests. The effective date is November 8, 2007. http://a257.g.akamaitech.net/7/257/2422/01jan20071800/edocket.access.gpo.gov/2007/pdf/E7-19312.pdf

NRC Regulatory Guides

The Regulatory Guide series provides guidance to licensees and applicants on implementing specific parts of the NRC's regulations, techniques used by the NRC staff in evaluating specific problems or postulated accidents, and data needed by the staff in its review of applications for permits or licenses. Potentially relevant divisions include Power Reactors, Environmental and Siting, Transportation, and Occupational Health. Selected Regulatory Guides related to Environment and Siting are identified below. Access to all Regulatory Guides is available at the following website:

(http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/)

- Regulatory Guide 4.1, Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants (Rev. 1)

- Regulatory Guide 4.2, Preparation of Environmental Reports for Nuclear Power Stations (Rev. 2)

- Regulatory Guide 4.2S1 (09/2000), Supplement 1 to Regulatory Guide 4.2, Preparation of Supplemental Environmental Reports for Applications To Renew Nuclear Power Plant Operating Licenses

- Regulatory Guide 4.7, General Site Suitability Criteria for Nuclear Power Stations (Revision 2, 04/1998); useful in evaluating site selection process and evaluation of alternative sites

- Regulatory Guide 4.11, Terrestrial Environmental Studies for Nuclear Power Stations (Rev. 1)

NUREG Series Publications

The NUREG series includes reports or brochures on regulatory decisions, results of research, results of incident investigations, and other technical and administrative information. Selected publications relating to licensing of nuclear power plants are identified below. All publications (and full listing of available publications) are accessible through links found at the following website:

http://www.nrc.gov/reading-rm/doc-collections/nuregs/

- NUREG 0586: Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities (August 1988)
http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0586/

- NUREG 0800: Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants (Revised March 2007). Includes detailed information relating to plant components and description.
http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/

- NUREG 1437: Generic Environmental Impact Statement for License Renewal of Nuclear Plants. Includes links to 33 supplements, each of which is specific to a particular power plant. Information may be useful in understanding existing site conditions for those new units proposed at an existing nuclear power plant site that has been relicensed. In addition, impacts from plant operation are expected to be similar to those from operation of a new unit (in many instances).
http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1437/)

- NUREG 1555 (March 2000 and Supplement 1): Standard Review Plans for Environmental Reviews of Nuclear Power Plants (Environmental Review Guidance Document). The Environmental Standard Review Plan (ESRP) is prepared for the guidance of NRC staff responsible for environmental reviews for nuclear power plant license applications. The ESRP is not a substitute for regulatory guides or the Commission's regulations and compliance with them is not required. The ESRP is key to preparation of environmental reports for nuclear power stations, information from which NRC staff use to prepare the EIS. At present, sections of the ESRP are being revised to reflect new information and experience. Draft Revision 1 of these sections can be accessed at
http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1555/

Other NRC Resources

- Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions (69 FR 52040, August 24, 2004). NRC's policy statement includes

its consolidated views on how it will treat environmental justice matters in agency regulatory and licensing actions. NRC recognizes that the impact of the agency's regulatory or licensing actions on certain populations may be different from those on the general population due to a community's distinct cultural characteristics. The policy statement reflects the view that the disproportionately high and adverse impacts of a proposed action that fall heavily on a particular community call for close scrutiny under NEPA. ESRP 2.5.4 (NUREG 1555) contains procedures for identifying and describing minority and low-income populations that could be impacted by a proposed action: sections 4.4.3 and 5.8.3 cover the subsequent staff assessment and evaluation of specific impacts for plant construction and operation, respectively.
http://www.epa.gov/fedrgstr/EPA-IMPACT/2004/August/Day-24/i19305.htm

- Groundwater Contamination (Tritium) at Nuclear Plants
  Tritium is a mildly radioactive type of hydrogen that occurs both naturally and during the operation of nuclear power plants. Water containing tritium and other radioactive substances is normally released from nuclear plants under controlled, monitored conditions the NRC mandates to protect public health and safety. The NRC recently identified several instances of unintended tritium releases, and all available information shows no threat to the public. Nonetheless, the NRC is reviewing these incidents to ensure nuclear plant operators have taken appropriate action and to determine what, if any, changes are needed to the agency's rules and regulations. This website provides further basic information on tritium and other isotopes released from nuclear power plants, outlines the status of the unintended tritium leaks and the NRC's actions.
  http://www.nrc.gov/reactors/operating/ops-experience/grndwtr-contam-tritium.html

- Early site permit (ESP) documentation for:

  - Clinton ESP Site (Exelon Generating Company), NUREG 1815 (EIS) and NUREG 1844 (Safety Evaluation Report)
    http://www.nrc.gov/reactors/new-licensing/esp/clinton.html

  - Grand Gulf ESP Site (System Energy Resources), NUREG 1817 (EIS) and NUREG 181840 (SER)
    http://www.nrc.gov/reactors/new-licensing/esp/grand-gulf.html

  - North Anna ESP Site (Dominion Nuclear), NUREG 1811 (EIS) and NUREG 1835 (SER)
    http://www.nrc.gov/reactors/new-licensing/esp/north-anna.html

  Note that these sites will also be submitting (or already have submitted) combined operating license (COL) applications, for which new NRC EISs will be developed, and which will also rely on the analysis done in the ESP EIS to the extent possible.

- COL Application Guidance

  NRC has developed or is currently developing guidance for COL applicants that will be applicable to any anticipated COL application. NRC is focused on including the public in the development of this guidance. Current efforts include the following:

  - Interim staff guidance associated with COL and design certification for new reactor applicants
    http://www.nrc.gov/reading-rm/doc-collections/isg/col-app-design-cert.html

  - Regulatory guides related to the COL application guidance. (The staff is currently evaluating certain regulatory guides for adequacy for use in new reactor licensing. An evaluation may not necessarily result in revision to a guide.)
    http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/

  - Regulatory Guide 1.206, ―Combined License Applications for Nuclear Power Plants."
    http://www.nrc.gov/reactors/new-licensing/new-licensing-files/rg1206-table-of-contents.pdf

- Agencywide Documents Access and Management System (ADAMS): ADAMS is an information system that provides access to all image and text documents that the NRC has made public since November 1, 1999, as well as bibliographic records (some with abstracts and full text) that the NRC made public before November 1999 (but most documents released before November 1999 are not available). The NRC continues to add several hundred new documents daily. ADAMS permits full-text searching and enables users to view document images, download files, and print locally.
  http://www.nrc.gov/reading-rm/adams.html

Certified Designs

- 10 CFR Part 52
  Appendix A to Part 52—Design Certification Rule for the U.S. Advanced Boiling Water Reactor
  Appendix B to Part 52—Design Certification Rule for the System 80+ Design
  Appendix C to Part 52—Design Certification Rule for the AP600 Design
  Appendix D to Part 52—Design Certification Rule for the AP1000 Design
  Appendixes E through M to Part 52 [Reserved]
  Appendix N to Part 52—Standardization of Nuclear Power Plant Designs: Combined Licenses to Construct and Operate Nuclear Power Reactors of Identical Design at Multiple Sites
  http://www.nrc.gov/reading-rm/doc-collections/cfr/part052/full-text.html5cFR

- Nuclear Energy Institute

    - Near-Term Advanced Nuclear Plant Designs – the nuclear industry has developed several advanced reactor designs that can be ready to meet U.S. generating needs by 2015: U.S. EPR, ABWR, ESBWR, U.S.-APWR, AP1000.
    - Longer-Term Advanced Nuclear Plant Designs – the industry also is developing highly advanced new reactors based on new technologies. Some could be ready for commercial use in the U.S. by the end of the next decade, while others are not likely to be available before 2030: AREVA Antares gas-cooled helium reactor, GT-MHR, PBMR, IRIS

  http://www.nei.org/keyissues/newnuclearplants/newreactordesigns/

- U.S. Department of Energy, Energy Information Administration
  New Reactor Designs
  http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss_2.html

EPA Regulations and Tools

Section 316(b) of the *Clean Water Act* states that ―any standard established pursuant to section 301 or section 306 of this Act and applicable to a point source shall require that the location, design, construction, and capacity of cooling water intake structures reflect the best technology available for minimizing adverse environmental impact.”

EPA developed implementing regulations under the NPDES permitting program as follows (please note that new NPPs are most likely covered under the Phase I regulation); see www.epa.gov/waterscience/316b/ :

- The Phase I rule (see 40 CFR Subpart I) published in December 2001 instituted national technology-based performance requirements applicable to the location, design, construction, and capacity of cooling water intake structures at new facilities. These national requirements establish the best technology available for minimizing adverse environmental impact associated with the use of these structures.

- The Phase II rule (see 40 CFR Subpart J), published in February 2004, covering large existing electric generating plants, in which EPA established location, design, construction, and capacity standards for cooling water intake structures. In March 2007, EPA suspended the Phase II regulations in response to the 2nd Circuit Court of Appeals decision in *Riverkeeper, Inc., v. EPA*, 358 F.3d 174 (2^{nd} Cir. 2004), and directed staff to use a best professional judgment basis for identifying applicable permit conditions. See EPA‘s website for the current status of the Phase II regulation (www.epa.gov/waterscience/316b/phase2/).

- The Phase III rule (40 CFR Subpart N) published in June 2006 covers intake structures at new offshore oil and gas extraction facilities that have a design intake flow threshold of greater than 2 million gallons per day and that withdraw at least 25 percent of the water exclusively for cooling purposes.

- Facilities with cooling water intake structures not subject to national categorical regulations will continue to be addressed under 40 CFR 125.90(b) and 401.14 on a best professional judgment basis.

In some cases, Section 316(a) of the *Clean Water Act* allows for a variance from thermal effluent limitations in an NPDES permit if the facility can demonstrate that the alternative effluent limitation desired by the discharger, considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected, will assure the protection and propagation of a balanced indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge is to be made (see 40 CFR 125 Subpart H).

EPA has also developed NEPAssist, a web-based GIS application to facilitate the environmental review process and project planning in relation to environmental considerations. NEPAssist draws environmental data dynamically from web-based databases and provides immediate screening of environmental resource information for a user-defined area of interest. For further information, contact Aimee Hessert, EPA Office of Federal Activities, at hessert.aimee@epa.gov or (202) 564-0993.

U.S. Department of Energy

- Energy Information Administration: Reports address electric power generation statistics and topics such as ―When Do Commercial Reactors Permanently Shut Down?", and include the useful summary of New Reactor Designs at
  http://www.eia.doe.gov/cneaf/nuclear/page/analysis/nucenviss_2.html
  http://www.eia.doe.gov/fuelnuclear.html

- Office of Nuclear Energy: Information on the Advanced Fuel Cycle Initiative, Generation-IV technologies, the Global Nuclear Energy Partnership, laboratory facilities management, the Isotope Program, the Nuclear Hydrogen Initiative, nuclear fuel supply security, Nuclear Power 2010, and radioisotope power systems.
  Reports include the following:
  - A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010 (Volumes I and II)
  - U.S. Department of Energy/Nuclear Power Industry, Strategic Plan, For Light Water Reactor Research and Development
  - The Economic Future of Nuclear Power Study conducted by the University of Chicago
  - NP2010 Improved Construction Technologies, O&M Staffing and Cost, Decommissioning Costs, and Funding Requirements Study conducted by Dominion Energy
  - DOE NP2010 Nuclear Power Plant Construction Infrastructure Assessment
    http://www.ne.doe.gov/default.html

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Appendix I. Siting Conditions

This appendix describes site conditions that should be considered during the siting of a nuclear power plant, including hydrology, geology, hydrochemical conditions, soil conditions, meteorological conditions, or other technical aspects.

Appendix I. Siting Conditions

- Existing Regulations and Guidance
- Geology and Seismology
- Meteorological Conditions
- Hydrology
- Other Technical Aspects Related to Siting

Existing Regulations and Guidance

Siting factors and criteria are important in assuring that radiological doses from normal operation and postulated accidents will be acceptably low. Regulations and guidance related to siting nuclear power plants do not include threshold values for seismic, hydrological, or meteorological parameters that would be considered faulty or unacceptable for siting a power plant (for example, no maximum wind speed or minimum water availability is described in the regulations). Rather, the regulations require that natural phenomena and potential man-made hazards will be appropriately accounted for in the design of a plant (10 CFR 100.1).

10 CFR Part 100, "Reactor Site Criteria," requires that the population density; use of the site environs, including proximity to man-made hazards; and the physical characteristics of the site, including seismology, meteorology, geology, and hydrology, be taken into account in determining the acceptability of a site for a nuclear power reactor. Subpart B, ―Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997," lists the factors that the NRC currently considers in determining the acceptability of a site. Seismic and geologic site criteria for nuclear power plants are provided in 10 CFR 100, Appendix A. 10 CFR Part 50, ―Domestic licensing of production and utilization facilities", Appendix S provides Earthquake Engineering Criteria for Nuclear Power Plants. This presentation of site conditions follows the categories presented in 10 CFR Part 100.

Regulatory Guide 4.7, ―General Site Suitability Criteria for Nuclear Power Stations" (NRC 1998), discusses the major site characteristics related to public health and safety and environmental issues that the NRC staff considers in determining the suitability of sites for light-water-cooled nuclear power stations. These guidelines may be used by applicants in identifying the initial stage of selecting potential sites. This guide does not discuss details of the engineering designs required to ensure the compatibility of the nuclear station and the site or the detailed information required for the preparation of the safety analysis and environmental reports. This 1998 guide is scheduled to be updated by the end of calendar year 2009 (NRC 2008). This guide, in addition to the regulatory requirements described above, serves as a key source of information for describing site conditions herein.

A more in-depth understanding of siting criteria as they affect plant design can be obtained from the Standard Review Plans for Safety Analysis Reports and Environmental Reports. Applicants for nuclear power plant licenses are required to provide information on site characteristics in the Final Safety Analysis Report (FSAR), which is a requirement of the application process for a new nuclear power plant. In Chapter 2 of the FSAR, ―Site Characteristics and Site Parameters", the applicant should provide information concerning the geological, seismological, hydrological, and meteorological characteristics of the site and vicinity, in conjunction with present and projected population distribution and land use and site activities and controls. The purpose of this information is to demonstrate that the applicant has accurately described the site characteristics and appropriately used them in the plant design and operating criteria (NRC 2007a).

The amount of data and analysis required to establish site characteristics and site-related design parameters for a proposed site is enormous. (Chapter 2 of the FSAR for Bellefonte Units 3 and 4 COLA is 811 pages.) NUREG 0800, –Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (NRC 2007a) describes the information requirements and acceptance criteria for each section of the FSAR, including 30 sections for Chapter 2. The Standard Review Plan contains a vast amount of information on the siting criteria that is not included in regulatory Guide 4.7. For example, the Standard Review Plan describes acceptable measurements and models used to predict upstream dam failure, whereas Regulatory Guide 4.7 notes that evaluation of flood hazards should consider the potential for upstream dam failure. When information from Regulatory Guide 4.7 is used, related sections of NUREG 0800 and other guidance documents are referred to for more detailed information.

Regulatory Guide 1.206, –Combined License Applications for Nuclear Power Plants" (NRC 2007b), Section C.I.2. –Site Characteristics", explains the information requirements for completing Chapter 2 of the Final Safety Analysis Report (FSAR) for COL applicants.

Information on site conditions is also required in an EIS for a new nuclear power plant. NUREG 1555, –Standard Review Plan for Environmental Reviews for Nuclear Power Plants," provides guidance to NRC staff in implementing provisions of 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," related to new site/plant applications. This guidance document describes the information and acceptability criteria for geological and meteorological site conditions presented in an EIS; however, the geology section is brief and refers the user to the safety analysis reports (NRC 2000, Sections 2.6 and 2.7).

Geology and Seismology

10 CFR 100.23, Geologic and Seismic Siting Criteria, –sets forth the principal geologic and seismic considerations that guide the NRC in its evaluation of the suitability of a proposed site and adequacy of the design bases established in consideration of the geologic and seismic characteristics of the proposed site, such that there is a reasonable assurance that a nuclear power plant can be constructed and operated at the proposed site without undue risk to the health and safety of the public" (10 CFR 100.23). –The geologic and seismic siting factors considered for design must include a determination of the Safe Shutdown Earthquake Ground Motion for the site, the potential for surface tectonic and nontectonic deformations, the design bases for seismically induced floods and water waves, and other design conditions" such as soil and rock stability, liquefaction potential, natural and artificial slope stability, cooling water supply, and remote safety-related structure siting (10 CFR 100.23(d)). Each of these factors is discussed in the following sections.

Safe Shutdown Earthquake Ground Motion

“Safe shutdown earthquake ground motion is the vibratory ground motion for which certain structures, systems, and components are designed to remain functional” (10 CFR 50 Appendix S). 10 CFR 100.23 requires applicants for an ESP, COL, construction permit, or operating license to determine the Safe Shutdown Earthquake Ground Motion. Safe Shutdown Earthquake Ground Motion for the site is characterized by both horizontal and vertical free-field ground motion response spectra at the free ground surface[13]. Data on the vibratory ground motion is obtained by reviewing pertinent literature and carrying out field investigations. Uncertainties are considered inherent and must be addressed through an appropriate analysis, such as a probabilistic seismic hazard analysis or suitable sensitivity analyses (10 CFR 100.23).

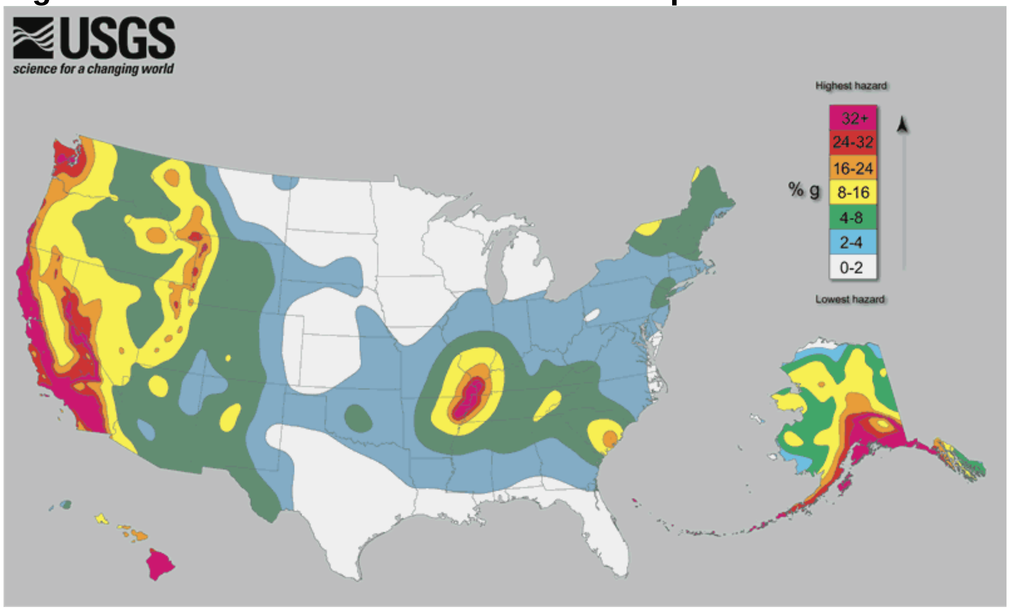
Determination of the Safe Shutdown Earthquake Ground Motion is design-dependent and it is not possible to quantify a threshold for ground motion that would be considered a faulty site condition. Appendix A to Part 100, “Seismic and Geologic Siting Criteria for Nuclear Power Plants,” describes the required investigations. Regulatory Guide 1.165, "Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion” provides general guidance on procedures acceptable to the NRC staff to satisfy the requirements of 10 CFR 100.23 (NRC 1997). In addition, Regulatory Guide 1.208, “A Performance-Based Approach to Define the Site-Specific Earthquake Ground Motion” (NRC 2007c), incorporates developments in ground motion estimation models, updated models for earthquake sources, methods for determining site response, and new methods for defining a site-specific performance-based Ground Motion Response Spectra. This regulatory guide is considered as an alternative guidance rather than replacement for Regulatory Guide 1.65.

The Standard Review Plan for Environmental Reviews for Nuclear Power Plants, NUREG 1555 (NRC 2000, Section 2.6), states that no description of the site geology is required in an EIS, because this information can be referenced from the safety evaluation report (SER) or site safety evaluation report (SSER). NUREG 0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” includes a section on reviewing basic geologic and seismic information. It describes the regional and site geology information collected by applicant for a construction permit, operating license, design certification, ESP, or COL. It provides the NRC reviewer guidance for determining the acceptability of the information, methods, and determination of the geologic and seismic suitability of the site as provided by the applicant in the FSAR (NRC 2007a, Section 2.5.1).

Though a site- and design-specific seismic hazard analysis is required, the U.S. Geological Survey (USGS) seismic hazard assessment for the U.S. is shown in Figure 1 to give a broad view of high hazard areas. According to the USGS, their more detailed hazard maps serve as the basis for seismic provisions used in building codes and influence billions of dollars of new construction every year (USGS 2007).

[13] Ground Motion Response Spectra is defined as: “Site-specific ground motion response spectra characterized by horizontal and vertical response spectra determined as free-field motions on the ground surface or as free-field outcrop motions on the uppermost in-situ competent material using performance-based procedures” (NRC undated). A response spectrum is a “plot of the maximum responses (acceleration, velocity, or displacement) of idealized single-degree-of-freedom oscillators as a function of the natural frequencies of the oscillators for a given damping value. The response spectrum is calculated for a specified vibratory motion input at the oscillators' supports” (10 CFR 50 Appendix S).

Figure 1. USGS National Seismic Hazard Map



Source: USGS 2007 (http://earthquake.usgs.gov/research/hazmaps/products_data/index.php).
Note: The ground motion units are g where 1g = 980.5 cm/s/s.

Potential for Surface Tectonic and Non-Tectonic Deformations

Tectonic movement, such as surface faulting, can cause a change in the volume or shape of a body of rock, known as deformation. Distortion of surface or near-surface soils or rocks can also be caused by non-tectonic activity. ―Such deformation includes features associated with subsidence, karst terrain, glaciation or deglaciation, and growth faulting” (NRC 2007c). 10 CFR 100.23 (d) (2) requires determination of the potential for surface tectonic and nontectonic deformations. Sufficient geological, seismological, and geophysical data must be provided to clearly establish whether there is a potential for surface deformation. Appendix A to Part 100, ―Seismic and Geologic Siting Criteria for Nuclear Power Plants,” describes the required investigations.

Preferred sites are those with a minimal likelihood of surface or near-surface deformation and a minimal likelihood of earthquakes on faults in the site vicinity (within a radius of 8 km). License applications musts present sufficient data to justify whether or not surface faulting needs to be taken into account in the design bases. ―Where it is determined that surface faulting must be taken into account, the applicant shall, in establishing the design bases for surface faulting on a site, take into account evidence concerning the regional and local geologic and seismic characteristics of the site and any other relevant data” (10 CFR 100, Appendix A).

―Because of the uncertainties and difficulties in mitigating the effects of permanent ground displacement phenomena such as surface faulting or folding, fault creep, subsidence or collapse, NRC considers it prudent to select an alternative site when the potential for permanent ground displacement exists at the site” (NRC 1998). However, this is not a requirement. ―Sites located near geologic structures, for which at the time of application the data base is inadequate to determine their potential for causing surface deformation, are likely to be subject to a longer licensing process in view of the need for extensive and detailed geologic and seismic investigations of the site and surrounding region and for the rigorous analyses of the site-plant combination” (NRC 1998).

NUREG 0800, ―Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” describes the review and acceptance procedures that NRC follows in evaluating the site characterization information and findings submitted by the applicant related to surface deformation due to faulting (NRC 2007a, Section 2.5.3).

Seismically Induced Floods and Water Waves

As with other geologic siting criteria, the potential for seismically induced floods or water waves does not preclude a site from consideration. 10 CFR 100.23(d)(3) requires determination of design bases for seismically induced floods and water waves. ―The size of seismically induced floods and water waves that could affect a site from either locally or distantly generated seismic activity must be determined” (10 CFR 100.23(d)(3).

10 CFR 100, Appendix A includes requirements for the determination of design bases for seismically induced floods and water waves. The size of seismically induced floods and water waves which could affect a site from either locally or distantly generated seismic activity shall be determined, taking into consideration the results of specific required investigations. Local topographic characteristics that might tend to modify the possible runup and drawdown at the site must be considered. ―Adverse tide conditions shall also be taken into account in determining the effect of the floods and waves on the site. . . The characteristics of the earthquake to be used in evaluating the offshore effects of local earthquakes shall be determined by a procedure similar to that used to determine the characteristics of the Safe Shutdown Earthquake” (10 CFR 100, Appendix A).

Other siting criteria for seismically induced floods, and floods caused by other factors are discussed under Section 4.0 Hydrology, below.

Soil and Rock Stability

―Sites with competent bedrock generally have suitable foundation conditions. In regions with few or no such sites, it is prudent to select sites with competent and stable solid soils, such as dense sands and glacial tills... [A] detailed geologic and geotechnical investigation is required to determine static and dynamic engineering properties of the material underlying the site in accordance with 10 CFR 100, Appendix A” (NRC 1998).

Vibratory ground motion associated with the Safe Shutdown Earthquake can cause soil instability due to ground disruption such as fissuring, differential consolidation, liquefaction, and cratering that is not directly related to surface faulting. 10 CFR 100, Appendix A describes the geologic features that must be evaluated to determine their affect on the foundations of a proposed nuclear power plant. These features include: ―[(1)] areas of potential subsurface subsidence, uplift, or collapse resulting from natural [(for example, tectonic depressions)] or human activity [(such as withdrawal of fluid from the subsurface)]; [(2)] deformational zones such as shears, joints, fractures, folds, or combinations of these features; [(3)] zones of alteration or irregular weathering profiles and zones of structural weakness composed of crushed or disturbed materials; [(4)] unrelieved residual stresses in bedrock; or [(5)] rocks or soils that might be unstable because of their mineralogy, lack of consolidation, water content, or potentially undesirable response to seismic or other events" (10 CFR 100, Appendix A).

Liquefaction Potential

"If bedrock sites are not available, it is prudent to select sites in areas known to have a low subsidence and liquefaction potential. Investigations will be required to determine the static and dynamic engineering properties of the material underlying the site as stated in Appendix A to 10 CFR Part 100 and 10 CFR 100.23" (NRC 1998). Regulatory Guide 1.198, "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plant Sites," describes acceptable methods for evaluating potential for earthquake-induced instability of soils resulting from liquefaction and consequent strength degradation (NRC 2003).

Natural and Artificial Slope Stability

Failure of a natural or artificial slope could adversely affect a nuclear power plant. 10 CFR 100, Appendix A provides requirements for determining slope stability. Stability of all slopes, both natural and artificial, must be considered. Licensees must assess the potential effects of erosion or deposition. The assessment must also include combinations of erosion or deposition with seismic activity, taking into account information concerning the physical property of the materials underlying the site (10 CFR 100, Appendix A).

Seismic and Geologic Siting Criteria Related to Cooling Water Supply

A nuclear power plant requires adequate cooling water supply for emergency and long-term shut down decay heat removal. 10 CFR 100, Appendix A provides requirements for determining cooling water supply related to seismic and geologic siting criteria. Geological characteristics of a site can have an effect upon cooling water supply; therefore, licensees must take in to account information concerning the physical properties of the materials underlying the site. River blockage or diversion or other failures that may block the flow of cooling water; coastal uplift or subsidence, or tsunami runup and drawdown; and failure of dams and intake structures shall be included in the evaluation, where appropriate (10 CFR 100, Appendix A). Other factors influencing cooling water supply are discussed in the Hydrology section, below.

Seismic and Geologic Siting Criteria for Remote Safety-Related Structures

Those "structures that are not located in the immediate vicinity of the site but that are safety-related shall be designed to withstand the effect of the Safe Shutdown Earthquake and the design basis for surface faulting determined on a comparable basis to that of the nuclear power plant, taking into account the material underlying the structures and the different location with respect to that of the site" (10 CFR 100, Appendix A).

Meteorological Conditions

Meteorology is among the physical characteristics to be considered in determining site suitability (10 CFR 100.20). Meteorological characteristics of the site that are necessary for safety analysis or that may have an impact upon plant design (such as maximum probable wind speed and precipitation) must be identified and characterized.

Applications for site approval for commercial power reactors shall demonstrate that the proposed site meets specific criteria related to meteorology (10 CFR 100.21). First, site atmospheric dispersion characteristics must be evaluated and dispersion parameters established. It must be established that radiological effluent release limits associated with normal operation from the type of facility proposed to be located at the site can be met for any individual located offsite; and radiological dose consequences of postulated accidents shall meet specific criteria(10 CFR 50.34). Second, the meteorology must be evaluated and site parameters established such that potential threats will pose no undue risk to the type of facility proposed to be located at the site (10 CFR 100.21).

Atmospheric Extremes

> The potential effect of natural atmospheric extremes (such as tornadoes and exceptional icing conditions) on the safety-related structures of a nuclear station must be considered. However, the atmospheric extremes that may occur at a site are not normally critical in determining the suitability of a site because safety-related structures, systems, and components can be designed to withstand most atmospheric extremes...
>
> Local fogging and icing can result from water vapor discharged into the atmosphere from cooling towers, lakes, canals, or spray ponds, but can generally be acceptably mitigated by station design and operational practices. However, some sites have the potential for severe fogging or icing because of local atmospheric conditions. For example, areas of unusually high moisture content that are protected from large-scale airflow patterns are most likely to experience these conditions. The impacts are generally of greatest potential importance relative to transportation or electrical transmission systems in the vicinity of a site [NRC 1998].

Regional climatology, local meteorology, and onsite meteorological measurement programs must be described in a site's FSAR. NUREG 0800 describes acceptable sources for meteorological and climatological data and acceptable methods of data analysis (NRC 2007a).

Dispersion

The atmospheric conditions at a site should provide sufficient dispersion of radioactive materials released during a postulated accident to reduce the radiation exposures of individuals at the exclusion area and low population zone boundaries to specific values (NRC 1998). Dispersion should be sufficient such that an individual located at any point on the boundary of the exclusion area for any two-hour period following the onset of the postulated fission product release would not receive a radiation dose in excess of 25 rem total effective dose equivalent and an individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage) would not receive a radiation dose in excess of 25 rem total effective dose equivalent (10 CFR 50.34). If the dispersion of radioactive material released following a design basis accident is insufficient at the boundary of the exclusion area or the outer boundary of the low population zone, the plant design would not satisfy the requirements in 10 CFR 50.34. “In this case, the design of the station would be required to include appropriate and adequate compensating engineered safety features” (NRC 1998).

Atmospheric characteristics at a site are also important in evaluating the dispersion of routine releases in gaseous effluents. The atmospheric data necessary for assessment of the potential dispersion of radioactive material are described in Regulatory Guide 1.23, "Meteorological Monitoring Programs for Nuclear Power Plants” (NRC 2007d). In the evaluation of potential sites, onsite meteorological monitoring can determine if the atmospheric conditions at a site are adequately represented by the available atmospheric data for the area. “Canyons or deep valleys frequently have atmospheric variables that are substantially different from those variables measured for the general region. Other topographical features such as hills, mountain ranges, and lake or ocean shorelines can affect the local atmospheric conditions at a site and may cause the dispersion characteristics at the site to be less favorable than those in the general area or region. More stringent design or effluent objectives may be required in such cases” (NRC 1998).

An applicant‘s Environmental Report should identify the regional and local atmospheric transport and diffusion characteristics to be considered in the assessment of the population doses likely to result from plant operation. NUREG 1555, “Standard Review Plan for Environmental Reviews for Nuclear Power Plants,” describes the data requirements and atmospheric dispersion models to be used in calculating doses resulting from accidental and routine releases (NRC 2000, Section 2.7). NUREG 0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” describes the information requirements and acceptance criteria for the short-term dispersion estimates for accident releases and long-term atmospheric dispersion estimates for routine releases described in the site‘s safety analysis report (NRC 2007a, Sections 2.3.4 and 2.3.5).

Air Quality

Air quality is unlikely to be an important consideration for nuclear power station siting unless a site is in an area where existing air quality is near or exceeds standards, or there is a potential for interaction of the cooling system plume with a plume containing noxious or toxic substances from a nearby facility. If a nuclear power plant‘s auxiliary generators are expected to operate routinely, air quality may become a siting consideration (NRC 1998). The FSAR (depending upon whether or not an ESP is referenced in a construction permit, operating license, or COL application) is required to include a detailed description of the site‘s air quality, including identification of the site‘s Air Quality Control Region and its attainment designation with respect to state and national ambient air quality standards (NRC 2007a, Section 2.3.2).

<u>Background Salt Concentrations</u>

> A cooling system designed with special consideration for reducing drift may be required because of the sensitivity of the natural vegetation or the crops in the vicinity of the site to damage from airborne salt particles. The vulnerability of existing industries or other

facilities in the vicinity of the site to corrosion by drift from cooling tower or spray system drift should be considered. Not only are the amount, direction, and distance of the drift from the cooling system important, but the salt concentration above the natural background salt deposition at the site is also important in assessing drift effects. None of these considerations are critical in evaluating the suitability of a site, but they could result in special cooling system design requirements or in the need for a larger site to confine the effects of drift within the site boundary. The environmental effects of salt drift are most severe where saline water or water with high mineral content is used for condenser cooling [NRC 1998].

Visibility

Cooling towers produce cloud like plumes that vary in size and altitude depending on the atmospheric conditions. The plumes are often a few miles in length before becoming dissipated, but the plumes themselves or their shadows could have aesthetic impacts. Visible plumes emitted from cooling towers in the vicinity of airports could cause a hazard to aviation [NRC 1998].

Hydrology

Flooding

Criteria for evaluation of seismically induced floods under 10 CFR 100.23 are discussed under ―Seismic and Geologic Siting Criteria”, above.

Nuclear power plants should be designed to prevent the loss of capability for cold shutdown and maintenance thereof resulting from the most severe flood conditions that can reasonably be predicted to occur at a site as a result of severe hydrometeorological conditions, seismic activity, or both. Regulatory Guide 1.59, "Design Basis Floods for Nuclear Power Plants," describes an acceptable method of determining the design basis floods for sites along streams or rivers and discusses the phenomena producing comparable design basis floods for coastal, estuary, and Great Lakes sites (NRC 1977). This guide is scheduled to be updated by 2009 (NRC 2008) and should be supplemented by best current practices (NRC 2007a, Section 2.4.2).

―The effects of a probable maximum flood (as defined in Regulatory Guide 1.59), seiche[14], surge, or seismically induced flood such as might be caused by dam failures or tsunamis on station safety functions can generally be controlled by engineering design or protection of the safety-related structures, systems, and components” (NRC 1998). ―However, analyses of only the most severe flood conditions may not indicate potential threats to safety-related systems that might result from combinations of flood conditions thought to be less severe. Therefore, reasonable combinations of less-severe flood conditions should also be considered to the extent needed for a consistent level of conservatism” (NRC 1977). Applicants are required to include site-specific information related to flooding and to document and justify the design bases of affected facilities in the Site Safety Analysis Report. NUREG 0800, ―Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants” (NRC 2007a), describes the

[14] An oscillation of the surface of a landlocked body of water (as a lake) that varies in period from a few minutes to several hours.

information requirements and acceptance criteria for each section of the FSAR, with significant detail on floods in Section 2.4.

Water Availability

Seismic and geologic siting criteria related to water availability are discussed under *Seismic and Geologic Siting Criteria*, above.

Nuclear power plants require sufficient water be available for steam condensation, service water, emergency core cooling system, cooling during plant operation and normal shutdown, fire protection, and other functions. Nuclear power plants also require water for ―ultimate heat sink" functions. The ultimate heat sink typically consists of an assured supply of water that is credited for dissipating reactor decay heat and essential station heat loads after a normal reactor shutdown or a shutdown following an accident or transient, including a loss-of-coolant accident (NRC 1998, NRC 2007a). Though no minimum water availability is established for siting a nuclear power plant, the design criteria must take into consideration water availability. Recirculating hot cooling water through cooling towers, artificial ponds, or impoundments can be used where water supply is limited (NRC 1998). Drought has become a recent concern for existing nuclear power plants relying on river and lake water in the southeastern U.S. (Weiss 2008).

The limitations imposed by existing laws or allocation policies govern the use and consumption of cooling water at potential sites for normal operation.

> Consumption of water may necessitate an evaluation of existing and future water uses in the area to ensure adequate water supply during droughts for both station operation and other water users (that is, nuclear power station requirements versus public water supply). Regulatory agencies should be consulted to avoid potential conflicts...
>
> To evaluate the suitability of sites, there should be reasonable assurance that permits for consumptive use of water in the quantities needed for a nuclear power plant of the stated approximate capacity and type of cooling system can be obtained by the applicant from the appropriate state, local, or regional agency. Where required by law, demonstration of a request for certification of the rights to withdraw or consume water and an indication that the request is consistent with appropriate state and regional programs and policies is to be provided as part of the application for a construction permit or operating license...
>
> A highly dependable system of water supply sources must be shown to be available under postulated occurrences of natural and site-related accidental phenomena or combinations of such phenomena.... The availability of essential water during periods of low flow or low water level is an important initial consideration for identifying potential sites on rivers, small shallow lakes, or along coastlines. Both the frequency and duration of low flow or low-level periods should be determined from the historical record and, if the cooling water is to be drawn from impoundments, from projected operating practices [NRC 1998].

License applications must include a section on Low Water Considerations in the Safety Analysis Report. NUREG 0800, ―Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (NRC 2007a, Section 2.4.11), describes in detail the information requirements and acceptance criteria for Low Water Considerations, and also provides guidance for evaluating the capability of water sources for performing the “ultimate heat sink” function. Regulatory Guide 1.27, "Ultimate Heat Sink for Nuclear Power Plants" (NRC 1976), also provides guidance on water supply for the ultimate heat sink and discusses the safety requirements.

Water Quality

Surface Water Quality

Since adequate design strategies can be implemented to meet *Clean Water Act* requirements and NRC NEPA regulations, surface water quality is not generally a determining factor in assessing the suitability of a site (NRC 1998).

> Thermal and chemical effluents discharged to navigable streams are governed by the *Clean Water Act*, 40 CFR Part 122, 40 CFR Part 423, and state water quality standards. The applicant should also determine whether there are other regulations that are current at the time sites are under consideration. Section 401(a)(1) of the *Clean Water Act* requires, in part, that any applicant for an NRC construction permit, ESP, or COL for a nuclear power station provide to the NRC certification from the state that any discharge will comply with applicable effluent limitations and other water pollution control requirements. In the absence of such certification, no construction permit, ESP, or COL can be issued by NRC unless the requirement is waived by the state or the state fails to act within a reasonable period of time. A National Pollution Discharge Elimination System (NPDES) permit to discharge effluents to navigable streams pursuant to Section 402 of the *Clean Water Act* may be required for a nuclear power station to operate in compliance with the Act, but it is not a prerequisite to an NRC construction permit, operating license, or COL [NRC 1998].

Ground Water Quality

Factors important to hydrological radionuclide transport (such as soil, sediment, and rock characteristics, adsorption and retention coefficients, ground water velocity, and distances to the nearest surface body of water) must be obtained from on-site measurements (10 CFR 100.20). The hydrogeological characteristics of a site are evaluated in an applicant‘s safety analysis report. NUREG 0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” describes the information requirements and acceptance criteria related to evaluating movement of contaminants in groundwater (NRC 2007a, Section 2.4.12).

Other Technical Aspects Related to Siting

Population Considerations

“Locating reactors away from densely populated centers is part of the NRC's defense-in-depth philosophy and facilitates emergency planning and preparedness as well as reduces potential doses and property damage in the event of a severe accident” (NRC 1998).

10 CFR 100.20 —Factors to be considered when evaluating sites" under Subpart B, —Evaluation Factors for Stationary Power Reactor Site Applications on or After January 10, 1997," takes the population density into consideration in determining the acceptability of a site. Specifically, population density and use characteristics of the site environs, including the exclusion area, the population distribution, and site-related characteristics must be evaluated to determine whether individual as well as societal risk of potential plant accidents is low, and that physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans are identified (10 CFR 100.20).

Safety Analysis Reports are required to provide details on population density and distribution and to project future population density and to analyze site impacts in relation to this information (NRC 2007b, Section 2.1.3). Preferably a reactor would be located so that, at the time of initial site approval and within about 5 years thereafter, the population density, including weighted transient population, averaged over any radial distance out to 20 miles (cumulative population at a distance divided by the circular area at that distance), does not exceed 500 persons per square mile. A reactor should not be located at a site whose population density is well in excess of the above value (NRC 2007a, NRC 1998)

> If the population density of the proposed site exceeds but is not well in excess of preferred values, the analysis of alternative sites should pay particular attention to alternative sites having lower population density. However, consideration could be given to other elements such as safety, environmental, or economic factors, which may result in the site with the higher population density being found acceptable. Examples of such factors include, but are not limited to, the higher population density site having superior seismic characteristics, better railroad or highway access, shorter transmission line requirements, or less environmental impact upon undeveloped areas, wetlands, or endangered species [NRC 2007b].

Industrial, Military, and Transportation Facilities

The nature and proximity of man-related hazards (such as airports, dams, transportation routes, military and chemical facilities) must be evaluated to establish site parameters for use in determining whether a plant design can accommodate commonly occurring hazards, and whether the risk of other hazards is very low (10 CFR 100.20).

> The acceptability of a site depends on establishing that (1) an accident at a nearby industrial, military, or transportation facility will not result in radiological consequences that exceed the dose guideline in 10 CFR 50.34; (2) the accident poses no undue risk because it is sufficiently unlikely to occur (less than about 10^{-7} per year); or (3) the nuclear power station can be designed so its safety will not be affected by the accident....
>
> Potentially hazardous facilities and activities within 5 miles of a proposed site, and major airports within 10 miles of a proposed site, should be identified. If a preliminary evaluation of potential accidents at these facilities indicates that the potential hazards from shock waves and missiles approach or exceed those of the design basis tornado of the region or if potential hazards exist such as flammable vapor clouds, toxic chemicals, or incendiary fragments, the suitability of the site should be determined by a detailed evaluation of the degree of risk imposed by the potential hazard [NRC 1998].

Socioeconomics

Social and economic issues are important determinants of siting policy. The siting, construction, and operation of a nuclear power station may place severe stresses on the local labor supply, transportation facilities, and community services in general. There may be changes in the tax basis and in community expenditures, and problems may occur in determining equitable levels of compensation for persons relocated as a result of the station siting. It is usually possible to resolve such difficulties by proper coordination with impacted communities; however, some impacts may be locally unacceptable and too costly to avoid by any reasonable program for their mitigation. Evaluation of the suitability of a site should therefore include consideration of purpose and probable adequacy of socioeconomic impact mitigation plans for such economic impacts on any community where local acceptance problems can be reasonably foreseen (NRC 1998).

Certain communities in the neighborhood of a site may be subject to unusual impacts that would be excessively costly to mitigate. Among such communities are towns that possess notably distinctive cultural character, that is, towns that have preserved or restored numerous places of historic interest, have specialized in an unusual industry or avocational activity, or have otherwise markedly distinguished themselves from other communities (NRC 1998).
Siting decisions should reflect fair treatment and meaningful involvement of all people, regardless of race, ethnicity, culture, income, or educational level to assure equitable consideration and to minimize disproportionate effects on minority and low-income populations (NRC 1998).

Security Plans

Site characteristics must be such that adequate security plans and measures can be developed (10 CFR 100.21). –Based on experience and analysis, the NRC staff has found that a distance of about 110 meters (360 feet) to any vital structure or vital equipment generally would provide sufficient space to satisfy security measures specified in 10 CFR 73.55 (for example, protected area barriers, detection equipment, isolation zones, vehicle barriers). Since the distance to the nearest exclusion area boundary is considerably greater than 110 meters (360 feet), the site characteristics are not normally limiting with regard to the ability to develop adequate security plans" (NRC 1998).

Emergency Plans

Physical characteristics unique to the proposed site that could pose a significant impediment to the development of emergency plans must be identified (10 CFR 100.21) –An examination and evaluation of the site and its vicinity, including the population distribution and transportation routes, should be conducted to determine whether there are any characteristics that would pose a significant impediment to taking protective actions to protect the public in the event of emergency. Special population groups, such as those in hospitals, prisons, or other facilities that could require special needs during an emergency, should be identified. Physical characteristics of the proposed site that could pose a significant impediment to taking protective measures, such as egress limitations from the area surrounding the site, should be identified" (NRC 1998).

Ecological Systems and Biota

"The ecological systems and biota at potential sites and their environs should be sufficiently well known to allow reasonably certain predictions that there would be no unacceptable or unnecessary deleterious impacts on populations of important species or on ecological systems with which they are associated from the construction or operation of a nuclear power station at the site. When early site inspections and evaluations indicate that critical or exceptionally complex ecological systems will have to be studied in detail to determine the appropriate plant designs, proposals to use such sites should be deferred unless sites with less complex characteristics are not available" (NRC 1998).

References

Links to external web sites provided in this document may be useful or interesting and are being provided consistent with the intended purpose of this guidance document. EPA cannot attest to the accuracy of information provided by any linked site. Providing links to a non-EPA web site does not constitute an endorsement by EPA or any of its employees of the sponsors of the site or the information or products provided on the site. Also, be aware that the privacy protection provided on the epa.gov domain (see Privacy and Security Notice) may not be available at the external link.

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